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ORIGINAL ARTICLES.

I.—Fossils from the Hindu Khoosh.

By Lieut.-Gen. C. A. McMahon, F.R.S., F.G.S., and W. H. Hudleston, M.A., F.R.S., F.L.S., F.G.S.

Part II.—Palæontology. By Mr. Hudleston.

(PLATES II and III.)

THE Himalayas, with the help of that singular replica of the more mountainous region known as the Salt Range, have afforded to the palæontologist, in one place or another, a fairly good series of the several Palæozoic horizons.

1. *The First Palæozoic Horizon.*—The lowest Cambrian, or *Neobolus*-fauna, perhaps the lowest recognized fauna in the world, is to be found in the Salt Range in immediate succession to the Salt series. This fauna was discovered by Warth, and has been elucidated in the *Palæontologia Indica* at considerable length. In the volume for 1899 there is a plate of these fossils, which are described as consisting of simple forms like *Neobolus*, or rather complicated ones like *Pseudotheca*.

The Carboniferous overlap in the Salt Range, noticed by Waagen and confirmed by subsequent observers, has had the effect of shutting out the rest of the infra-Carboniferous horizons from that range, so that we there obtain nothing between the lowest Cambrian and the Carboniferous beds. On the other hand, I cannot find that the *Neobolus*-fauna has been recognized in the Himalayas proper.

2. *The Second Palæozoic Horizon.*—This must be sought in the Himalayas alone without the valuable confirmatory evidence supplied by the Salt Range in the case of the Carboniferous fauna.

A very valuable find of fossils belonging to this horizon, which in the main may be regarded as of Lower Silurian (Ordovician) age, was made by General Strachey some forty years ago in Niti. These were described and figured by Salter in a memoir printed for private circulation, to which H. F. Blanford contributed. To give an idea of the importance of this find, Salter enumerated some sixty species, as follows :—Crustacea 8 species, Annelida 2, Cephalopoda 8, Gasteropoda 11, Lamellibranchiata 3, Brachiopoda 21, Bryozoa 3, Amorphozoa 2, Zoophyta 2. Referring to the Brachiopoda only, *Leptæna*, *Strophomena*, and *Orthis* are perhaps

the best represented genera, and the fauna was regarded as most resembling Caradoc. Many of these fossils are in a fairly good state of preservation. The types are to be seen at the British (Natural History) Museum.

Shortly afterwards Stoliczka wrote a memoir on the Palæozoic formations in Spiti.[1] Here he came across a fossiliferous horizon which he called the *Bhabeh-series*, but the fossils were badly preserved. In his recapitulation Stoliczka described his Bhabeh-series as probably of Lower Silurian age, consisting of sandstones, slates, and quartzites, containing *Orthis* and other genera not specifically determinable.

Subsequently it is believed that important additions have been made to the collections from this horizon in the Himalayas, but at present these matters are in reserve. The following extract from Mr. R. D. Oldham's Manual,[2] published in 1893, bears upon this point. It occurs as a footnote. "A large number of fossils from General Strachey's collections were described by Messrs. Salter and Blanford in 1865, and the collections which were made by Griesbach, which are still in the course of description, will doubtless add to their number. Until this fauna has been worked out and its relations fully determined, there does not appear to be any benefit in printing a nominal list of the species that have been described."

3. *The Third Palæozoic Horizon.*—Like the second horizon, this has no replica in the Salt Range. So far as anything is known about it, we are still indebted to Stoliczka. Referring to his experiences in Spiti, he thus speaks of the *Muth-series*:—"Above the true Silurian rocks there will be found a thickness of beds, of about 1,000 feet, distinguished by a different shade of a bluish colour; their age is left undecided. The fossils of this series occur in an arenaceous limestone, some of the beds being of a purer limestone of a dark colour. Specific determination is not easy owing to the bad state of preservation."

Two species of *Cyathophyllum* were recognized, whilst the Brachiopoda were represented by *Strophomena* and two species of *Orthis*. In his summary Stoliczka regarded the Muth-series as of Upper Silurian age, and he correlated, as already stated by General McMahon, the middle or fossiliferous division of that series with the Blaini-limestone.

4. *The Fourth Palæozoic Horizon.*—This may be focussed under the general term of the *Kuling-series*. The fine collection of Carboniferous fossils sent by Colonel Godwin-Austen from Kashmir engaged the attention of Davidson many years ago.[3] A considerable number of these specimens may yet be seen in the Museum of the Geological Society. This very abundant and characteristic fauna is receiving ample attention from the writers in the *Palæontologia Indica*, supplemented as it is by the highly fossiliferous *Productus*-limestones of the Salt Range.

[1] Mem. Geol. Surv. India, vol. v, pt. 1.
[2] p. 115.
[3] Quart. Journ. Geol. Soc., vol. xx, p. 383, and vol. xxi, p. 492.

The preceding notice of the principal Palæozoic horizons in the north-west corner of India may, it is hoped, be useful before attempting to study General McMahon's collection in detail.

When these fossils were first placed in my hands I had no knowledge of any of the four Palæozoic horizons of India, with the exception of the last, and that only to a very slight extent. Naturally, therefore, I first of all tried the Carboniferous, though I was surprised at finding no species of *Productus* in the collection. After working on this tack for some time I found that there was nothing in Indian Carboniferous palæontology to encourage me to proceed. Accordingly I fell back on the Niti fauna of Lower Silurian age described by Salter. This seemed to be somewhat more hopeful, but at last I was driven to the conclusion that I could find nothing published on Indian palæontology which would throw any light on the Chitral fossils.

Trying nearer home, it soon became evident that there existed a certain relationship between these fossils and the recognized faunas of the Upper Silurian and Devonian as developed in our own country. The few Corals remind me of Wenlock species, whilst the Brachiopoda wear a Devonian aspect. This determination would bring the assemblage nearest to the Muth-series, though perhaps not actually identical with that scanty and ill-preserved fauna. As confirmatory evidence the fossils of the Muth-series are said to occur in an arenaceous limestone, some of the beds being of a purer limestone of dark colour.[1] The dark limestone corresponds very well with the matrix of the Chitral fossils. Moreover, it is interesting to remember that two species of *Cyathophyllum* are recorded from the Muth-series.

In the case of General McMahon's collection it cannot be said that the fossils are badly preserved; they are less drawn out and disfigured by pressure than many Devonian specimens from Devonshire or Cornwall. Some of the specimens remind one of Dudley fossils, except that the limestone is darker and probably more earthy. The specimens also in most cases are fairly free from matrix, and the numerous individuals of *Atrypa* are detached and clean. The shells are in the condition of calcite with a dark exterior. Unfortunately there are no good casts of interiors. The conclusions both in the case of Corals and Brachiopoda are largely based on external characters.

Enumeration and Description of the Fossils.

CORALS.

1. Favosites cf. cristata, Blumenbach. (Pl. II, Fig. 1.)

Favosites cristata: Brit. Foss. Cor. (Silurian), p. 260, pl. lxi, figs. 3, 4.

This identification rests mainly on comparison with specimens from the Wenlock Limestone of Dudley in my own collection. The external resemblance is very striking. There is less resemblance to the figures in the "British Fossil Corals." The following is the

[1] Vide supra, p. 50.

diagnosis of Edwards & Haime :—"Corallum dendroidal . . . . Calices somewhat unequal in size, often almost circular and with rather a thick margin." "This coral bears great resemblance to *Favosites* [*Pachypora*] *cervicornis* of the Devonian, and we were even doubtful as to its being specifically distinct from it; its calices are, however, less unequal in size and almost circular." *F. cristata* is said by these authors to occur likewise in the Devonian of the Ural Mountains.

In the specimen from Chitral a variation in the size of the calices in the left-hand branch of the corallum is observed, and this divergence of form may be held to favour the view as to its affinity with *Pachypora cervicornis*, so common in the Devonian of Torquay.

There is another specimen of *Favosites* (? *Pachypora*) in the collection, which is less markedly dendroid, and in which the calices are rather smaller; but this, I think, may be referred to the same species.

2. Cyathophyllum cf. truncatum, Linnæus. (Pl. II, Figs. 2, 3.)

Cyathophyllum truncatum : Brit. Foss. Cor. (Silurian), p. 284, pl. lxvi, figs. 5*a–c*.

Edwards & Haime's diagnosis is true of specimens from Chitral in the following particulars :—"Corallites regularly turbinate, not very tall, and narrow at their basis; walls covered with a thin epitheca, and presenting strongly marked accretion ridges . . . . central fossula large and rather deep . . . . septa (50 to 60) very closely set, and thick towards the circumference, rather thin towards the centre, rather unequal in length alternately; the largest reaching to the centre." On the other hand, there are minor points where Edwards & Haime's diagnosis can scarcely be said to apply, more especially as regards the flattening of the outer part of the calice.

The Chitral fossils greatly resemble specimens of *C. truncatum* from the Wenlock Limestone of May Hill, more than they do any Devonian species such as *Hallia Pengellyi* or *C. helianthoides*. *Cyathophyllum densum*, Lindström (Richthofen, China, Bd. iv, p. 65), may approximate.

There are five specimens in the collection which may be classed under this head, besides fragments of what may be other species of *Cyathophyllum*.

3. Cyathophyllum cf. articulatum, Wahlenberg. (Pl. II, Figs. 4, 5.)

Cyathophyllum articulatum : Brit. Foss. Cor. (Silurian), p. 282, pl. lxvii, figs. 1, 1*a*.

The corallites in the Chitral specimens are all detached, and hence taken singly do not compare well with the fine composite figures of Edwards & Haime. In other respects their diagnosis is fairly applicable. "Corallites sub-cylindrical, tall, presenting numerous prominent accretion ridges, and covered with a thin epitheca, through which the costæ are apparent. Calices circular, shallow." The state of preservation does not admit of further comparison. There is a specimen in my own (British) collection from Dudley or

May Hill, which is so like the Chitral specimens, even to the matrix, that only close examination would enable one to separate them.

Two or three specimens in General McMahon's collection may be thus referred.

BRACHIOPODA.

4. Orthis striatula, Schlotheim. (Pl. II, Figs. 6*a*, *b*, 7*a–c*.)

Orthis striatula, Schlotheim: British Devonian Brachiopoda, p. 87, pl. xvii, figs. 4–7.

Specimens of *Orthis* are rare in this collection, and owing to the slipping of the valves very much thrown out of shape. Hence the character of the ornamentation becomes the principal factor for specific determination. The smaller of the two figured specimens shows the *Orthis* hinge very distinctly, whilst the larger one fails in this respect. Davidson's diagnosis is sufficiently comprehensive—"Shell variable, usually transversely oval or elliptical, but at times the length is equal to or slightly exceeds the width." But for this I might have had some hesitation in thus classifying Fig. 6, which has a strong resemblance to *Orthis æquivalvis*, Dav. (Brit. Silur. Brach., p. 263, pl. xxx, figs. 9, 10). As regards the ornamentation, the following fairly well applies both to the larger and the smaller specimen: "Exteriorly, both valves are closely covered with numerous, fine, thread-like, rounded, radiating striæ, etc."

Genus SPIRIFER.

There are a great many specimens of *Spirifer* in General McMahon's collection, most of which can be focussed under some of the varieties of *Spirifer disjunctus*, Sowerby, as grouped by Davidson. In this respect it seems to me that Davidson has made his net a little too comprehensive.

5. Spirifer extensus, Sowerby. (Pl. II, Figs. 8*a–d*.)

Spirifera extensa, Sowerby: Trans. Geol. Soc., ser. II, vol. v, pl. liv, fig. 11.
Spirifer disjunctus, Sow., var. *extensa*, Sow.: Brit. Dev. Brach., p. 23, pl. v, fig. 11.

Width of figured specimen 40 mm., length 18 mm. This gives a ratio of width to length of rather more than 2 : 1. Shell alate; valves moderately convex with a deep sulcus in the ventral valve, whilst the dorsal valve has the mesial fold very prominent; hinge area narrow and nearly straight. The beak of the ventral valve is only slightly incurved, and but slightly projecting. There are about 45 radiating costæ of moderate salience on each valve, and this style of ornamentation is shared by the sulcus and mesial fold.

The Chitral fossil differs from the type-form of *S. extensus* chiefly in being somewhat less alate, and in having a more pronounced mesial fold and sulcus. In this respect it more resembles *S. calcaratus*, Sow., which Davidson likewise regards as a variety of the *disjunctus*-group. It must be noted that besides the alate character of this fossil (Fig. 8) the narrow hinge area and want of salience of the beak of the ventral valve serve to separate it from *Spirifer disjunctus* (Fig. 9).

There are two specimens in the collection.

6. Spirifer disjunctus, Sowerby. (Pl. II: Rhomboidal variety, Figs. 9*a–c*, 10.)

Spirifera disjuncta, Sow.: Trans. Geol. Soc., ser. II, vol. v, pl. liv, figs. 12, 13, and explanation of plate.

Spirifer disjunctus, Sow.: Davidson, Q.J.G.S., vol. ix (1853), p. 354, pl. xv, figs. 1, 2, 4; ibid., Brit. Dev. Brach., p. 23, pl. v, especially figs. 1, 4, and 5.

Spirifer Verneuili, Murchison: Kayser in Richthofen's China, Bd. iv, p. 88, pl. x, fig. 3.

Width of the larger figured specimen (Figs. 9*a–c*) 34 mm.; length 26 mm. This gives the width to length as 3 : 2 approximately. Shell rhomboidal, narrowing towards the anterior margin so as to produce a curved outline; valves moderately convex. The sulcus and mesial fold are moderately developed, and carry nearly the same ornaments as the rest of the shell (faintly seen in the specimen owing to attrition). These ornaments consist of from 50 to 55 regular and equidistant costæ. Hinge area wide and triangular, the ventral valve greatly overlapping.

(Quadrate variety, Figs. 11, 12*a–c*.)

This variety is shown on Davidson's plate in the Q.J.G.S. by the figs. 3 and 5, and in the Brit. Dev. Brach. on pl. v, fig. 6.

Ratio of width to length very nearly as 1 : 1. Shell quadrate, valves usually somewhat tumid. Sulcus in ventral valve wide and not very deep; fold on the opposite valve correspondingly wide; ornaments the same throughout. Area moderately wide and trigonal in shape; beak of ventral valve considerably produced and incurved.

There are about half a dozen specimens of the rhomboidal form in the collection from Chitral, and rather more of the quadrate form, together with some which may be deemed intermediate.

The geographical distribution of this species is interesting. Davidson's specimens were described from Kwang-si, a province in the south of China. Herr Kayser's illustrations of this species occupy more than half of a quarto plate from collections made by Richthofen in south-west China.

7. Spirifer, species. (Pl. III, Figs. 1*a–c*.)

Shell ovate; width to length rather less than 3 : 2. Ventral valve very tumid, and with umbo considerably incurved; area small and closed. Sulcus and mesial fold not very conspicuous. The ornaments consist of numerous fine radial striæ.

The restricted area and fine radial striæ, together with its ovate form, seem to separate this from the *disjunctus*-group. There is only one specimen, somewhat indifferently preserved. The internal mould, which is partly exposed, consists of a very black and probably impure limestone, the shell itself being constituted of a brownish calcite.

8. Athyris concentrica, Von Buch. (Pl. III, Figs. 2*a–c*.)

Terebratula concentrica, Von Buch: Ueber Terebrateln, p. 103, Berlin (1834).

Athyris concentrica, Von Buch: Brit. Dev. Brach., p. 14, pl. iii, figs. 11–15, 24.

The figured specimen conforms pretty well to the diagnosis given by Davidson, which at least should confirm the view that this shell is a species of *Athyris*. The following especially applies to our specimen:—"Beak tumid, moderately produced, incurved and truncated by a small circular aperture close to the umbone of the opposite valve; surface more or less deeply marked by numerous close, concentric, regular, imbricating laminæ of growth." In our shell there is just enough left of these imbricating laminæ in the sulcus of the ventral valve to show what the ornaments of the shell originally were.

There are three specimens in the collection, but this is the only one showing the concentric ornamentation.

9. ATHYRIS, species or variety. (Pl. III, Figs. 3*a–c*.)

This is a very strongly marked form, and might in some sense be described as an exaggerated variety of *A. concentrica*. The features of that species, such as the sinus on the ventral valve and the mesial fold on the dorsal valve, as likewise the imbricating concentric ornamentation, are intensified. The principal difference consists in the great predominance of the ventral valve in the region of the beak, almost recalling the outline of *Pentamerus*.

There is one specimen, in by no means a bad state of preservation.

Genus ATRYPA.

Nearly half the Brachiopoda in General McMahon's collection belong to this genus, and the specimens are for the most part free from matrix, whilst some are fairly well preserved. There is considerable uniformity as to size and shape, and the ornaments, as a rule, are strongly imbricated. Hardly any of the specimens present the fine lines of *Atrypa reticularis*, and moreover the prevailing shape is too circular for that species. The Chitral fossils more nearly approach *Atrypa aspera* and its numerous varieties, and under this species it will be convenient to focus the whole group.

10. ATRYPA ASPERA, Schlotheim. (Pl. III, Figs. 4, 5*a*, *b*, 6*a*, *b*, 7*a*, *b*.)

Atrypa aspera, Schlotheim: Brit. Dev. Brach., p. 57, pl. x, figs. 5, 6.
Ibid., var. *squamosa*, Sow.: Brit. Dev. Brach., p. 57, pl. x, figs. 7, 8.
Ibid., var. *Sinensis*, Kayser: Richthofen's China, Bd. iv, p. 83, pl. ix, fig. 3.

Davidson classified *Atrypa aspera* simply as a variety of *A. reticularis*, and he further remarks that it is always found in the same beds and localities where the latter occurs and abounds. The important point for us to consider is the fact that, whereas *A. reticularis* is equally abundant in the Upper Silurian and Devonian, *A. aspera*, be it species or variety, occurs mainly in the Devonian, its place in the Upper Silurian being occupied by *A. imbricata*, Sow. As to the existence of intermediate forms, no doubt the affinity of every variety of *Atrypa* may be traced to the prevailing form, viz. *reticularis*, if one is so inclined.

In dealing with the Chitral fossils, Fig. 5*a* may be accepted as an average specimen, very well preserved as regards ornaments, but

rendered somewhat quadrate in appearance by a slight slipping of the valves. The dorsal valve is shown with the very small beak of the ventral valve just projecting beyond the hinge-line. The radial costæ are salient, rounded, and highly imbricated, especially anteriorly (Fig. 5*b*).

In Fig. 6 we have a larger but less well-preserved fossil, and the original outline was probably less circular. This may be regarded as more nearly approaching *A. reticularis*; an enlargement, however, would show the costæ to be strongly imbricated and almost squamose. The valves as a rule are moderately tumid, the dorsal valve usually the most so.

Fig. 4 is a good example of the var. *squamosa*, Sowerby. In this case the circular outline is well shown, whilst the highly squamose character of the anterior portion of the shell is obvious.

Figs. 7*a*, *b* represent a perfectly circular and slightly globose form of medium size with very large imbricated costæ. This may be compared with the var. *Sinensis* of Kayser, though specimens from China would seem to have the dorsal valve less tumid.

11. Atrypa, species or variety. (Pl. III, Figs. 8*a–c*.)

This form is an exaggeration of the small circular variety of *Atrypa* last described. Both valves are extremely tumid, so that the shell is almost as globose as a ball. The only available specimen is much abraded, but it is possible to perceive that the costæ were highly imbricate, and that there are indications of a shallow sinus and slight mesial fold.

12. Cf. Rensslæria stringiceps, F. Römer. (Pl. III, Figs. 9*a–c*.)

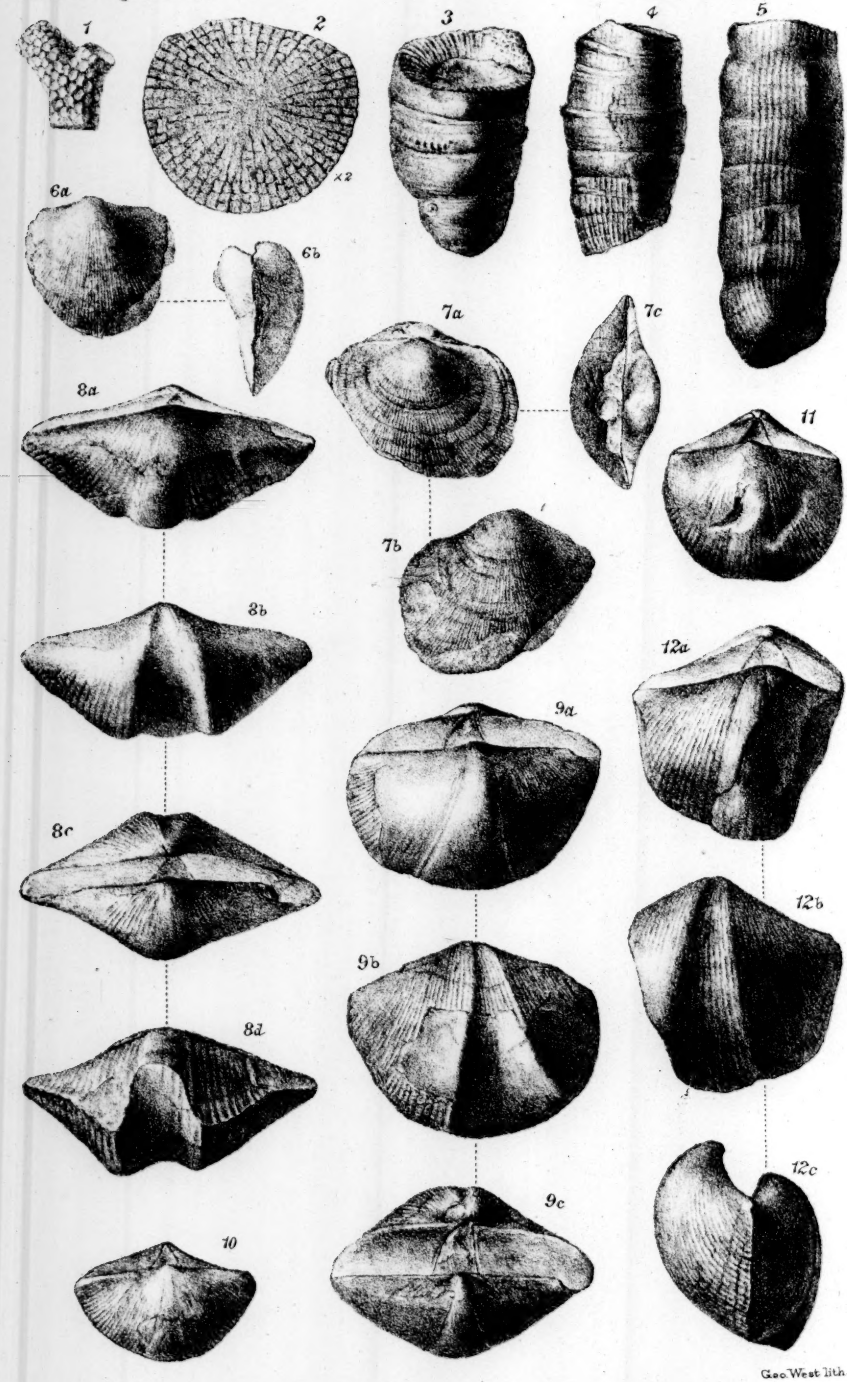
Rensslæria stringiceps ?, F. Römer: Brit. Dev. Brach., p. 10, pl. iv, figs. 5–7.

A single specimen, somewhat indifferently preserved in very black limestone, bears great resemblance to the fossil figured by Davidson under the above appellation. It is a terebratuloid shell, with a beak apparently possessed of a circular foramen: shape oblong, valves tumid, especially the dorsal valve. The dorsal valve swells out rapidly from the hinge area; the ventral valve has a slight median ridge, increasing in sharpness towards the beak. The valves are ornamented with strong radiating nodular costæ, about 20 in each valve.

13. Rhynchonella, species. (Pl. III, Figs. 10*a–c*.)

Shell transversely oblong; length 18 mm., estimated width 28 mm. Dorsal valve ventricose; ventral valve inclined to be flat, and provided with a wide, shallow sinus towards the anterior margin, which is only slightly sinuous. From 30 to 35 medium-sized costæ increase regularly towards the anterior margin without interpolation.

This is the only specimen in the collection which can be confidently referred to *Rhynchonella*. It is an average sort of form, which may possibly have some relationship to *R. parallelopipeda*, Bronn (vide Richthofen's China, Bd. iv, p. 77, pl. viii, fig. 1).



FOSSILS FROM THE HINDU KHOOSH.

Other Fossils.

In addition to the species already enumerated we perceive indications of other organized forms.

1. There are, for instance, other species of Brachiopoda, too obscure for identification.

2. Impressions of what seem to be crinoidal joints.

3. The frequent occurrence of *Spirorbis* as an adherent body. This is similar to those occurring on fossils from the Upper Silurian of Dudley, and also on Devonian fossils. Cf. Kayser in Richthofen's China, Bd. iv, p. 95, pl. xi, fig. 2, under the heading *Spirorbis omphalodes*, Goldf.?

4. The most interesting and abundant micro-organism is an incrusting Coral or Monticuliporoid, often well developed on the stem of *Cyathophyllum*. The size and character of the mesh resemble *Monticulipora* or *Chætetes*, but as the substance is too thin to bear cutting one can only conjecture its generic affinities.

A growth apparently identical in form is quite common on Corals from Dudley, and notably on a specimen of *Thecia* in my collection. In the British (Natural History) Museum there is a specimen of this incrusting organism on *Spirifer plicatella*. This specimen is labelled *Heterotrypa*, sp. (Allport, coll. D, 1752). The incrusting body on the Chitral fossils appears to be the same.

Conclusion.

There can be no doubt that these fossils from Chitral indicate the existence of a Devonian horizon in that region. The Brachiopoda are unmistakably Devonian, whilst the Corals, if rightly identified, point rather to species of Wenlock age. This difference may arise from one of three causes—either (1) the identification of the Corals is not wholly satisfactory; or (2) the Corals may have been obtained from slightly lower beds; or (3) there is a mixture of Upper Silurian and Devonian forms.

It must be distinctly understood that no attempt has been made to found new species. Identification, if only approximate, has been my object throughout. In the case of the first Coral enumerated (Pl. II, Fig. 1), it belongs to a form-group which may be either Silurian or Devonian, since we have the evidence of Edwards & Haime that they were doubtful if a true distinction could be made between *Favosites cristata* and [*Pachypora*] *cervicornis*, the one an Upper Silurian, the other a Devonian species.

The existence of a Devonian horizon in Eastern and Central Asia must henceforth be regarded as established beyond any doubt. Probably the first notice of the occurrence of Devonian fossils in China was given by De Koninck, who described a *Spirifer* and a *Rhynchonella* from Yunnan.[1] I have already referred to Davidson's recognition of Devonian fossils from the Chinese province of Kwang-si (near Canton). From south-western China Richthofen

[1] Bull. de l'Acad. Royale de Belgique, 1846.

obtained a large series of fossils, which Kayser regarded as Devonian. In vol. iv of Richthofen's China, Herr Kayser recognizes 14 species as previously known and 14 as new—all of Devonian age.[1] So much, then, for Devonian beds in China.

Proceeding westwards, we next find traces of a Devonian fauna in the Shan states of Burmah. The following is from a report of the Geological Survey of India (March 31, 1901) : "The occurrence of Devonian, which had been inferred by Mr. P. N. Datta, has been confirmed by Mr. La Touche, who found *Calceola sandalina*."[2] It is a far cry from northern Burmah to Chitral ; nevertheless, over a range of 2,000 miles from hard by the Pacific near Canton to the very centre of the Hindu Khoosh there are four or five points where a Devonian fauna has been proved to exist in regions not particularly accessible to the palæontologist. Our thanks are therefore due to General McMahon and his able coadjutors in Chitral for having brought this interesting series of fossils to light.

EXPLANATION OF PLATE II.

N.B.—All the figures are drawn from photographs ; except Fig. 2 they are all of natural size.

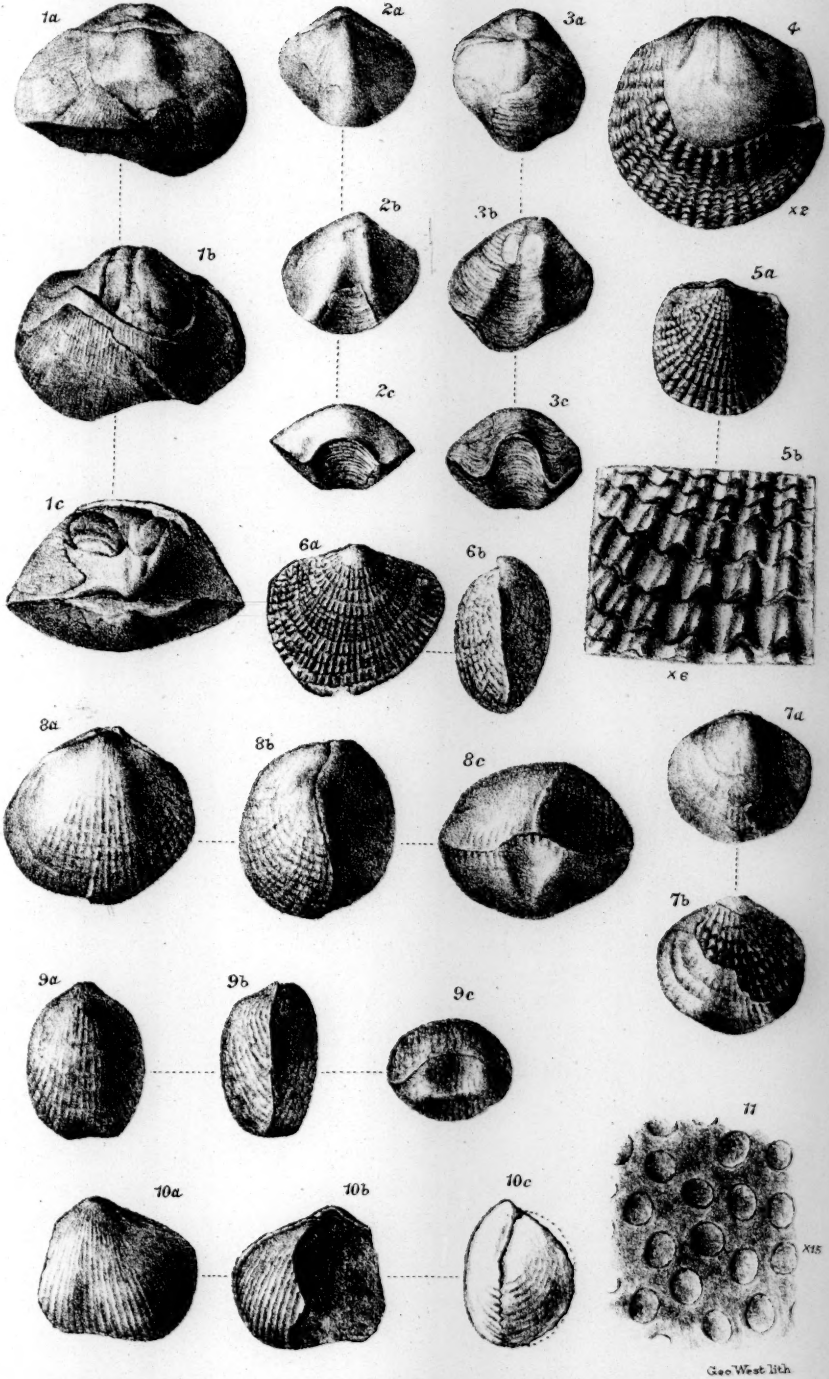
FIG. 1.—*Favosites* cf. *cristata*, Blumenbach. Portion of dendroid corallum.
FIG. 2.—*Cyathophyllum* cf. *truncatum*, Linnæus. Transverse section. × 2.
FIG. 3.—Ibid. Longitudinal view of another specimen, showing the calice.
FIG. 4.—*Cyathophyllum* cf. *articulatum*, Wahlenberg. Longitudinal view, showing accretion ridges.
FIG. 5.—Ibid. Another specimen with the ridges abraded.
FIGS. 6*a*, *b*.—*Orthis*, species ; ? small variety of *O. striatula*, Schlotheim.
FIGS. 7*a–c*.—*Orthis striatula*, Schlotheim.
FIGS. 8*a–d*.—*Spirifer extensus*, Sowerby.
FIGS. 9*a–c*.—*Spirifer disjunctus*, Sowerby. Rhomboidal or type form.
FIG. 10.—Ibid. A smaller specimen, with fine striæ.
FIG. 11.—Ibid. Quadrate form.
FIGS. 12*a–c*.—Ibid. A larger specimen of the quadrate form.

EXPLANATION OF PLATE III.

N.B.—All figures natural size, except Figs. 4, 5*b*, and 11, which last is cancelled.

FIGS. 1*a–c*.—*Spirifer*, species.
FIGS. 2*a–c*.—*Athyris concentrica*, Von Buch.
FIGS. 3*a–c*.—*Athyris*, species or variety.
FIG. 4.—*Atrypa aspera*, Schlotheim, var. *squamosa*, Sowerby. × 2.
FIG. 5*a*.—*Atrypa aspera*, Schlotheim. 5*b*, portion of test ; × 4.
FIGS. 6*a*, *b*.—*Atrypa aspera*, Schlotheim, approaching *Atrypa reticularis*, Linnæus.
FIGS. 7*a*, *b*.—*Atrypa aspera*, variety approaching var. *Sinensis*, Kayser.
FIGS. 8*a–c*.—*Atrypa*, species or variety.
FIGS. 9*a–c*.—Cf. *Rensslæria stringiceps*, F. Römer.
FIGS. 10*a–c*.—*Rhynchonella*, species.
FIG. 11.—Cancelled.

[1] I am indebted to Mr. R. Bullen Newton for drawing my attention to Herr Kayser's important work.
[2] *Nature*, Aug. 8, 1901, p. 359.



FOSSILS FROM THE HINDU KHOOSH.

II.—The Relation of Changes of Level to Interglacial Periods.

By Professor A. P. Coleman, Toronto University, Canada.

THE interesting paper on "The Connection of the Glacial Period with Oscillation of the Land," by Dr. Holst,[1] while reinforcing the quite probable theory that areas loaded with glacial ice sink under the burden, and after the ice has been thawed rise again, goes out of its way to deny the existence of Interglacial periods, probably with the idea that there was only one important sinking and rising in the Pleistocene, and hence no opportunity for Interglacial times. However that may be in Sweden, the evidence in favour of at least one important Interglacial period in North America is too strong to be set aside for any mere theory.

At the Meeting of the British Association in Toronto in 1897, a number of British geologists had an opportunity of seeing sections of the drift in the Don valley and at Scarboro' Heights near Toronto, which show a very extensive series of sediments, rich in fossils, lying between two well-defined sheets of Boulder-clay.

A committee was appointed to work out in detail the relationships of these Interglacial beds, and the secretary of the committee, the present writer, aided by generous grants from the Association, carried on a series of explorations the results of which were reported at the three following meetings. A detailed summing up of the facts observed, giving sections and lists of about 180 species of plants and animals, chiefly forest trees, fresh-water shellfish, and beetles, but including elephants, bison, and caribou, was published last Summer in the Journal of Geology.[2]

In a few words the general character of the facts observed may be given here, so that the strength of the evidence may be appreciated; and lest there should be any doubt as to the reality of the Interglacial position of the beds in question, it may be stated that they have been visited by numbers of glacialists from the United States as well as the Old World, some of them strongly opposed to the idea of Interglacial periods; but all have admitted that they are really Interglacial, though there have been differences of opinion as to whether the ice-sheet completely vanished during the time of their deposition, or merely withdrew to a greater or less distance and then advanced again.

The Interglacial beds consist mainly of a series of lake deposits, sands and clays, probably formed as a delta at the mouth of a large river. They are more than 186 feet in thickness at some points, and at least 18½ miles wide along the shore of Lake Ontario; while they have been traced inland more than 6 miles, beyond which they are buried under glacial materials.

At the base of the series, resting on an eroded surface of Boulder-clay, are 41 feet of the Don beds, containing, according to Professor

[1] Translation by Dr. F. A. Bather: Geol. Mag., May, 1901, pp. 205–216.

[2] "Glacial and Interglacial Beds near Toronto": Journ. Geol., vol. ix, No. 4, pp. 285–310.

Penhallow, an assemblage of forest trees like that of Ohio or Pennsylvania, some of them reaching their northern limit to the south of Toronto, others still growing in southern Ontario. One of them, *Acer pleistocenicum*, is extinct. Tree trunks 18 inches across are found at various levels in the Don beds, generally too much flattened by the pressure of the later ice-sheet to permit of counting their annual rings, though one that was better preserved than usual was found to have 120 rings in a width of 4 inches, and must have been 7 inches in radius when complete, i.e. 200 years old. These trees occur at the very bottom of the beds as well as at several levels above, and must represent different generations of forest. The upper or Scarboro' beds contain trees and other plants as well as beetles, of a cool temperate climate, like that of the north shore of Lake Superior, according to Dr. Macoun and Dr. Scudder. There are no Arctic nor sub-Arctic forms among them, and no glaciated pebbles nor ice-transported boulders; and the stratified clay is more ferruginous and less calcareous than any of our stratified glacial clays, burning to red brick instead of grey brick like the latter. The large river which formed the delta must have drained the upper lakes by a direct channel from Georgian Bay on Lake Huron to Scarboro' on Lake Ontario, and could not have drawn its waters from glacial sources.

It may be noted that at the very beginning of these Interglacial beds trees, such as three species of oak, an elm, the red cedar, and the pawpaw, were growing in the Don valley, showing that the climate was already warm, the last tree indicating a dry and hot Summer like that of Ohio. The isotherms evidently ran 150 miles north of their present position in eastern America.

Let us now turn to another side of the evidence. At the beginning of the deposits the water in the Ontario basin stood no higher than at present, perhaps lower, for streams eroded their channels through the Boulder-clay, and even 16 feet into the solid rock beneath, as shown in one of the Don sections. Afterwards the water in the basin rose to 60 feet above Lake Ontario at the end of the Don beds, and to 152 feet or more above that level before the close of the Scarboro' beds. There is no doubt about this point, for the deposits may be followed for miles with fine and even stratification, and could not have been formed by glacial rivers on a sloping land surface, as suggested by Mr. Warren Upham.[1]

Afterwards there was a fall in the level of the water to a point much below that of Ontario, and rivers had time to cut valleys more than 150 feet deep and from a mile to five miles in width through the Interglacial clay and sand. We have, therefore, an interval of erosion with low water after the retreat of the earlier ice-sheet before the warm-climate beds were laid down; and a very long stage of erosion with still lower water after the cold-temperate-climate beds were deposited; while there was a stage of high water between. How shall we account for these changes in the Interglacial water-levels?

[1] Amer. Geol., vol. xxviii, No. 5, p. 315.

Only two explanations have been suggested, an ice dam at the outlet of Lake Ontario, or an epeirogenic uplift of the region to the north-east, like that proved by Dr. Gilbert to be now going on in the Great Lakes region, followed by a sinking of the land again.

It seems incredible that after centuries, if not thousands, of years of hot summers like those of Pennsylvania the ice-sheet should still be lingering at the Thousand Islands, and should even advance 50 miles to the south, forming a wall of ice 200 or more feet thick across the powerful Interglacial St. Lawrence river. If the ice could thus advance during the warm climate epoch, why did it withdraw again after the climate had become cooler?

The improbabilities of the ice-dam theory are too great, and we must turn to the other theory of an uplift to the north-east followed by a depression for a satisfactory solution of the problem. Here a point of interest in connection with Dr. Holst's thesis makes its appearance. If during the warm Interglacial period there was a great differential uplift toward the north-east, was it not due to the thawing of the Labradorean ice-sheet, supposed to have been a mile or even two miles thick, and the resulting relief from pressure?

The supposition seems probable; and, since the water was ponded back to a height more than 150 feet above the present level, may we not suppose that Labrador toward the end of the time of deposit stood hundreds and possibly thousands of feet higher than now? Such an elevation towards the north-east would have rendered the climate of Labrador much colder; and, perhaps aided by changes in the constitution of the atmosphere or other causes, may have started a fresh accumulation of ice, which as it thickened pressed down the region and thus drained off the Interglacial lake and allowed rivers to cut their valleys.

Finally, the last ice-sheet, after advancing over the whole region, thawed, and the slow elevation toward the north-east began again. The distortion of the old Iroquois beach, as shown by the work of Drs. Spencer and Gilbert, gives an idea of how much elevation has been regained, and Dr. Gilbert's work in connection with lake-levels proves that the process is still going on; though the last vestige of the Labradorean ice-sheet long ago disappeared.

Apparently these changes of level are very much in arrears of the changes of load, and it may take even thousands of years for the earth's crust to readjust itself after a burden has been removed. We must not think of the solid rock or lithosphere as a thin crust resting on a molten layer, but as merging downwards into a plastic layer—Dr. Murray's tectosphere—which can yield to long-applied pressure and flow sluggishly to each side. After the pressure is removed, it returns in an equally sluggish way. If this conception of earth-movements is correct, the idea of motions due to the elasticity of the crust, like a pendulum set free, as suggested by Dr. Holst, must be abandoned. The rocks forming the lithosphere are not appreciably elastic, nor is the tectosphere a fluid that responds quickly to changes by successive waves slowly dying out. The

surface cannot rebound beyond the level appropriate to its specific gravity, but is likely through friction to halt somewhat below that point.

It is probable that the return of the plastic substratum after the load has been removed is not at a uniform rate, perhaps because of halts in the recession of the ice or even of temporary advances during the time of general retreat; and thus the successive marine terraces found, for instance, on the lower St. Lawrence would be accounted for.

One other point seems worthy of discussion, as to whether the pre-Glacial and Interglacial elevation of the north-east of America was sufficient to account for an Ice Age without other aid. The evidence of the submerged channels of the St. Lawrence and other rivers points to a former elevation of about 3,000 feet above the present level. It is doubtful if that would place Labrador above snow-line under existing climatic conditions, since the present level of the country is not more than one or two thousand feet. Snow-line in the Rocky Mountains and Selkirks at the same latitude ranges from 9,000 to 7,500 feet; and even with the difference due to cold oceanic currents, 4,000 or 5,000 feet seems too low an average level for perpetual snow in central Labrador.

The elevation of Scandinavia, where there are now mountains 8,000 feet high, with numerous snowfields 3,000 or 5,000 feet higher, would no doubt under present conditions produce a great extension of the ice, perhaps covering most of the land; but would it push ice-sheets across the Baltic and North Sea to Germany and England? This seems very improbable; and some supplemental cause should perhaps be sought for, but a discussion of such wide questions would lead us too far.

III.—On an *Alveolina*-Limestone and Nummulitic Limestones from Egypt.

By Frederick Chapman, A.L.S., F.R.M.S.

Part I.

THE following description of Egyptian foraminiferal limestones is based on a series of specimens transmitted to me by Dr. H. Woodward, F.R.S., on behalf of Captain H. G. Lyons, F.G.S.

The series comprises specimens from the Eocene and Miocene of the eastern side of the Red Sea Hills, collected by Mr. Thomas Barron, F.G.S.; and specimens from the Eocene of the east side of the Nile, between Assiut and Qena, and from the Baharia and Farafra Oases, collected by Mr. H. J. L. Beadnell, F.G.S. A great amount of interest attaches to these rocks, both as regards their general character and preservation, and also with respect to their microzoic contents.

The present series of rock-specimens may be described as follows:—

No. 2,195, 1*h*. "*Heterostegina*-limestones, 2 kilometres north-west of Camp 49, Wadi Dara, east of Red Sea Hills. Outlier of Miocene on Eocene and Cretaceous" (T. Barron). (Pl. IV, Fig. 1.)

An ochreous limestone, partly dolomitic. The interstitial material originally calcitic, but now largely replaced by minute rhombohedral crystals of dolomite. A few subangular and rounded quartz-grains also occur in this rock, the larger ones exhibiting a coarse polysynthetic structure under polarized light, such as may be seen in fragments derived from secondary quartz-veins.

The *Heterosteginæ* have been subjected to some considerable amount of pressure and are more or less deformed; the thin discoidal tests are often bent, and occasionally fractured over and against the larger quartz-grains. The tests of *Heterostegina depressa* constitute a large proportion of the limestone, perhaps as much as 90 per cent. Associated with the *Heterosteginæ* we notice many specimens of *Amphistegina Lessonii*, and in one section of the rock a crushed specimen of *Alveolina* was noted, presumably derived. Besides the foraminifera, there are several sections of polyzoa and some traces of lamellibranch shells.

Miocene.

No. 1,622, 56*h*, and No. 1,622, 6*k*. "Limestone under Eocene nodular bed near Jebel Hamrawein" (T. Barron). (Pl. IV, Fig. 2.)

This limestone contains a large proportion of a small variety of *N. curvispira*. There are apparently no other organisms present in the rock. The groundmass of this limestone is well crystallized, and contains numerous brown, indefinite-shaped glauconite grains. The specimen 56*h* contains nodules of chert which show a gradual passage from the limestone into the chert, the latter being isomorphous with the former as regards the organic contents. In the passage zone between the limestone and the chert a great deal of dolomite is present in the form of small rhombohedral crystals. In connection with these facts it is worth noting similar occurrences in many of the Devonian and Carboniferous cherts of England, and it seems to point to a certain sequence of chemical changes which occur in the silicification of limestones.

Middle Eocene: Mokattam Series.

No. 3,535, 52*l*. "Nummulitic limestones with bryozoa. Corner of cliff north of Salamuni, between Assiut and Qena, east side of Nile" (H. J. L. Beadnell). (Pl. IV, Fig. 3.)

A pure white chalky or earthy limestone with many nummulites, both large and small, and some *Operculinæ*. The groundmass of this rock is very finely crystalline, and was most probably a chalky mud in its original condition. It contains *Operculina complanata* var. *pyramidum*, *Nummulites Beaumonti*, and *N. sub-Beaumonti*.

Eocene: Upper Libyan or Lower Mokattam Series.[1]

[1] The fauna of this and the following specimens appears to be homotaxial in part with the Lower Mokattam beds found farther to the north, and this view is shared by Mr. Beadnell, who has written to me on the subject in a letter dated 6th April, 1901.

Box G, No. 1,467*d*. "Nummulites from a locality 39 kilometres west of Bawitti, on plateau west of Baharia Oasis" (H. J. L. Beadnell).[1]

A collection of nummulites of one kind, namely, *N. Gizehensis* var. *Pachoi*; these specimens are greatly worn and sand-polished. Also a small fragment of limestone crowded with specimens of *N. curvispira*.

Eocene: Upper Libyan or Lower Mokattam Series.

Box M, No. 1,480*e*. "*Operculinæ* and nummulites, 39 kilometres west of Bawitti, on plateau west of Baharia Oasis" (H. J. L. Beadnell). (Pl. IV, Fig. 4.)

The micro-structural features of this limestone are rather peculiar. Apparently the interstitial mud has crystallized round the nummulites, and during this process the cement has contracted so as to leave interspaces in the rock. The resultant cavities have subsequently been partially or entirely filled with little geodes of secondary quartz, showing a polysynthetic type of structure under polarized light with the microscope. This condition of the limestone seems to render it almost proof against weathering action. The rock is rather variable in its colour and appearance, and presents a pale cream to a dark reddish tint, due to the varying amounts of iron-staining. The surfaces of some of the rock-specimens are wind-polished. In mineralogical structure some of the samples have almost passed into the condition of Beekite.

The following foraminifera occur in this rock: *Textularia* ? *gramen*, *Globigerina bulloides*, *Operculina complanata* var. *discoidea*, *Nummulites Gizehensis* var. *Pachoi*, *N. curvispira*, *N. discorbina*, *N. subdiscorbina*, and *Orbitoides* (*Discocyclina*) *dispansa* (= *O. dilabida*, Schwager).

Eocene: Upper Libyan or Lower Mokattam Series.

Box M, Nos. 3,335*b* and *c*. "*Alveolina*-limestone, western wall of depression of Farafra Oasis (El-Guss-Abu-Said)" (H. J. L. Beadnell). (Pl. IV, Fig. 5.)

A white or pale cream-coloured limestone, having a soft crumbling texture, and crowded with *Alveolinæ*. The fractured surface of the rock is seen to be thickly studded with these foraminifera, or shows numerous cavities where they have dropped out. A rudely stratified structure is seen in weathered surfaces of this limestone, or where it has been subjected to wind-wearing action.

The groundmass of this rock seen under the microscope is finely granular, but crystalline; and the interior of the organisms are usually filled with calcite crystals, larger than those of the cement, a result of slower growth.

Four species of Ostracoda were found in the disintegrated rock, viz., *Bairdia subdeltoidea*, *B. Beadnelli* sp. nov., *B. minuta* sp. nov., and *Cythere farafrensis* sp. nov.

[1] In his paper on "Recent Geological Discoveries in the Nile Valley and Libyan Desert" (London, 1901), Mr. Beadnell refers in detail to the relations of the Cretaceous and Eocene at the above-named locality, and regards the nummulitic and *Operculina* limestones as Upper Libyan (p. 12 op. cit.).

As remarked above, the larger proportion of the rock is composed of foraminifera belonging to the genus *Alveolina*; but there are several other genera present, considerably smaller in size and much rarer. The list is as follows: *Miliolina inflata, Alveolina ellipsoidalis, A. decipiens, A. decipiens* var. *dolioliformis, A. pasticillata, Placopsilina cenomana, Valvulina Schwageri* sp. nov., *Bulimina elegantissima* var. *seminuda, Discorbina parisiensis, Truncatulina candidula, T. Ungeriana, Heterostegina depressa, Nummulites Biarritzensis* var. *præcursor.*

Eocene: Upper Libyan or Lower Mokattam Series.

Box M, No. 1,531*f*. "Nummulitic and *Operculina* limestone, 8 kilometres north of Mandisha, Baharia Oasis" (H. J. L. Beadnell).

A shaly, ochreous-stained limestone. Nummulites and *Operculinæ* largely make up the mass of the rock. A few fragments of a vesicular lamellibranch shell-structure (*Ostrea*?) occur in thin sections of this limestone.

The foraminifera yielded by this rock are: *Globigerina cretacea* (? derived), *Operculina complanata* var. *canalifera* (= *O. libyca*, Schwager), *Nummulites Ramondi*, and *N. variolaria.*

Eocene: Upper Libyan or Lower Mokattam Series.

Box M, No. 3,348*g*. "Nummulites and *Operculinæ*. Cliff 8 kilometres N.N.W. of Bawitti, Baharia Oasis" (H. J. L. Beadnell). (Pl. IV, Fig. 6.)

A pale ochre-yellow limestone with numerous cavities once occupied by nummulites and *Operculinæ*. The entire substance of this rock has undergone chemical and molecular change. The cementing material, as seen under the microscope, is recrystallized and dolomitized, whilst the cavities representing the nummulites and shells are either filled with calcite, or, as in the case of the larger nummulites and *Operculinæ*, represented only by hollow casts, or skeleton whorls bordered by dolomite rhombs. The surfaces of the cavities of the foraminiferal casts sometimes show a distinct septation, so much so as to leave no doubt regarding the identity of at least two species of the foraminifera.

The foraminifera present in this rock appear to be *Operculina complanata* var. *canalifera, Nummulites* ? *Biarritzensis* var. *præcursor*, and *N. Guettardi* var. *antiqua.*

Eocene: Upper Libyan or Lower Mokattam Series.

Box M, No. 1516*h*. "Nummulites, 17 kilometres N.N.E. of Ain-el-Haiss, Baharia Oasis" (H. J. L. Beadnell).

A series of nummulites comprising two species in about equal proportion, namely, *N. Beaumonti* and *N. sub-Beaumonti.*

Eocene: Upper Libyan or Lower Mokattam Series.

OSTRACODA.

BAIRDIA, McCoy [1844].

BAIRDIA SUBDELTOIDEA (Münster).

Jones & Sherborn, 1889: Monogr. Tert. Entom., Pal. Soc., p. 16, pl. i, figs. 15*a*, *b*.
Chapman, 1900: GEOL. MAG., Dec. IV, Vol. VII, p. 4.

A species nearly allied to the above, namely, *B. foveolata*, G. S. Brady, is found in recent deposits,[1] and our Egyptian specimens are not unlike it as regards the superficial markings on the carapace, but the lateral view of the recent species has an outline which is perhaps more nearly comparable with that of *B. subtrigona*, Bornemann.

Formerly recorded from Egypt from an *Alveolina*-limestone doubtfully referred to Lower Miocene, from a locality between Cairo and Suez.

Two specimens measuring in length 1·7 mm. and 1·2 mm. respectively.

Found in No. 3,335*b*, *Alveolina*-limestone. Farafra Oasis: Libyan Series.

BAIRDIA BEADNELLI, sp. nov. (Pl. V, Figs. 1*a–c*.)

Carapace elongated, somewhat compressed; height equal to half the length, and situated in front of the middle. Laterally the shape is somewhat amygdaloidal. Anterior extremity obliquely rounded and angulated at its junction with the dorsal margin; posterior, somewhat acute. Dorsal margin well arched, sinuated in front; ventral, straight or slightly convex towards anterior extremity. Outline seen from above compressed ovate, thickest in the middle. End view sub-spherical.

Length of largest specimen, 1·6 mm.; greatest height, ·9 mm.; thickness of carapace, ·73 mm.

In lateral aspect this species is not unlike *B. Crosskeiana*, Brady,[2] but without the denticuli on the ventral margin. The edge view of our specimens is, however, very different, the greatest thickness being in the middle of the carapace. This species is distinguished by the name of the collector of the specimens which have yielded so many interesting forms.

Found rarely in No. 3,335*b*, *Alveolina*-limestone. Farafra Oasis: Libyan Series.

BAIRDIA MINUTA, sp. nov. (Pl. V, Figs. 2*a–c*.)

Carapace compressed; seen from the side sub-trigonal. The anterior extremity rounded at the antero-ventral angle, and slightly sinuate on the opposite or antero-dorsal angle. The posterior extremity is acute and sinuate. The dorsal margin well arched in the middle, the ventral hollowed below the middle. Edge view sub-ovate, but thin; end view sub-oval.

Length, ·9 mm.; height, ·5 mm.; thickness, ·33 mm.

One example of this small but neatly-shaped form found in No. 3,335*b*, *Alveolina*-limestone. Farafra Oasis: Libyan Series.

CYTHERE FARAFRENSIS, sp. nov. (Pl. V, Figs. 3*a–c*.)

Carapace tumid, sub-quadrangular in its lateral aspect; greatest height in front, and equal to nearly two-thirds of the length. The anterior extremity somewhat straight and gently rounded at the

[1] G. S. Brady, 1880: Rep. Chall. Exp., Zool., pt. iii, p. 56, pl. viii, figs. 1*a–f*, 2*a–f*.

[2] Rep. Chall. Exp., Zool., pt. iii, p. 58, pl. ix, figs. 3*a–c*.

angles; posterior extremity narrower and rounder. Dorsal margin nearly straight, slightly incurved at the middle, where the anterior flange tapers off. Ventral margin straight, but in the lateral aspect encroached upon by the postero-ventral swelling. Surface of carapace gradually rising from the antero-dorsal angle toward the postero-ventral, where it is steep, and surmounts the posterior flange; somewhat pitted and having three or more small tubercles arranged in the centre of each valve. Outline, as seen from above, irregularly ovate, widest at the posterior third, the anterior extremity rapidly tapering and concave in that part of the outline; posteriorly the carapace ends in a blunt point. End view suborbicular and slightly wedge-shaped at the dorsal margin.

Length, ·76 mm.; height, ·5 mm.; thickness of carapace, ·53 mm.

From the *Alveolina*-limestone, No. 3,335*b*. Farafra Oasis: Libyan Series.

(*To be continued: the Plates will be given in our next Number.*)

IV.—The Zigzag Course of the Cheddar Gorge.

By C. Callaway, M.A., D.Sc., F.G.S.

HAVING undertaken to explain the geology of the Cheddar gorge to the Cotteswold Naturalists' Field Club at one of their field-meetings this Summer, I thought I should do so more intelligently if I first acquired a practical knowledge of my subject. I accordingly paid a preliminary visit to Cheddar. There were two chief questions to be investigated: (1) the origin of the gorge, and (2) the cause of its serpentine, or rather zigzag, course. The former inquiry had been answered in four different ways. There had been geologists who held that the valley had been excavated by the waves of the sea. A second school taught that it had been produced by a dislocation, splitting the rocks asunder. The third theory regarded it as a valley of erosion, excavated in the ordinary way by a river on the surface. A fourth explanation placed the river underground, and maintained that the glen had originally been a long winding cavern, the roof of which had subsequently fallen in.[1]

Very little investigation was needed to convince me that hypotheses one and two were of no value. My inquiry led me to consider that on the whole the cavern theory was most in accordance with the facts, and I provisionally adopted it in my subsequent exposition to the Club. I confess, however, that with my present knowledge of the locality I am unable to find a decisive preponderance of evidence in its favour, and I leave the question still open. I therefore limit myself in this paper to the second inquiry—the serpentine course of the gorge.

I felt some surprise to find that a stream running down so steep a slope should have described such rapid curves. The floor of the valley at its mouth, near where the underground river emerges at the surface, is 85 feet[2] above sea-level. In half a mile it rises to 340 feet, and in a mile to 500 feet, or a rise of 255 feet in the first half-mile and 160 feet in the second. Just beyond the mile, at

[1] See also Proc. Geol. Assoc., vol. xi, pp. ccvii and 493.

[2] The heights are taken from the 6-inch Ordnance Map.

Black Rock, the elevation is 511 feet, and, less than two miles due north of this point, the highest summit of the Mendips reaches 1,068 feet, or a rise of about 304 feet per mile. The slope in the lower half-mile of the gorge is therefore little less steep than the upper half of the side of the mountain. A stream running down this incline would be a torrent, and we should not expect it to meander rapidly in homogeneous rocks, whether it flowed above ground or below. A special cause of the curving or zigzagging was therefore to be looked for.

It is well known that the Cheddar gorge is excavated in the Carboniferous Limestone, that the strata dip at about 20° to the south or a little to the east of south, and that in a general way the valley runs along the strike, so that on the south side the outcropping strata overhang, and often form lofty cliffs, while on the north the beds slope gently down to the floor of the valley. A stream rushing rapidly along the strike of hard strata might be expected to carve out a tolerably straight course.

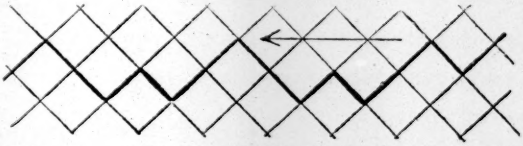
I ascertained that the serpentine course of the valley is caused by the jointing in the limestone. The rock is traversed by two systems of joints, which appear to be vertical or nearly so, intersecting approximately at a right angle. This fact presents itself at almost every turn in the glen. The joint-surfaces are seen to form salient and re-entrant angles, the former opposite the latter, so that if the two sides of the glen were brought together they would seem to interlock. This correspondence has probably given rise to the supposition that the gorge owes its origin to a zigzag rift, followed by a movement asunder of its two sides.

The joints are often closely approximated, so that, in quarrying, the limestone readily breaks away in cubical blocks. But this is not material to the problem. If the joints are not open ones, they will not admit the passage of water, and a rock traversed by them is practically impervious.

That the jointing has caused the zigzags in the glen is apparent, whether the stream flows above ground or below the surface. Take the former alternative. The general direction of the movement would be along the diagonals of the parallelograms made by the joints, for that is the direction of the present slope of the valley, and it is the direction supposed to be taken by the present subterranean river.[1] But the water would soak along open joints, and widen them into fissures, and the flow would be diverted into these fissures. The movement would be sometimes to the right, sometimes to the left; but it would always tend to return to the line of the diagonals. The stream, after flowing for some distance along an open joint or fissure (say) to the right, would be compelled by gravity to seek a passage to the left, and this would be afforded when the next fissure in that direction was reached. The natural course of the current would thus be determined by the open joints, and would follow a zigzag line. The channel thus produced would be gradually enlarged into a valley; but the aerial weathering would act along

[1] Buckland & Conybeare: Trans. Geol. Soc., ser. II, vol. i, pt. 2, p. 223, note.

joints, whether open or concealed, and the zigzag course would be maintained. The following figure illustrates my explanation.



Diagrammatic plan of part of the Cheddar Gorge, showing the rectangular jointing, the open joints followed by the stream being indicated by the thick lines. The arrow shows the direction of the slope.

The theory I have here expounded will apply still more aptly to the second alternative—that the valley was excavated by an underground river. Such a stream *must* have followed joints, for they are the only conceivable channels, and a succession of zigzags is the only form which the gorge could assume.

But it may be objected that the course of the stream which carved out the Cheddar glen was probably determined in an overlying formation, Cretaceous or Jurassic. Let us inquire how this hypothesis will work. Such a river flowed over a surface of Chalk or other Mesozoic sediment. Vertically above the line of the present glen it must *ex hypothesi* have described the same zigzags. It cut its way down lower and lower until it flowed over a surface of Carboniferous Limestone, and then it was found that the lines of the zigzags were parallel with the joints in the limestone. Such a coincidence is perhaps credible, but it demands the exercise of greater faith than my nature is able to command.

There is a second improbability in this hypothesis. Why do the zigzags stop at the mouth of the gorge? On my theory, this ought to be the case, because it is here that the limestone ends and the Trias comes in. But if the course of the river which excavated the valley had been determined on a Mesozoic surface, the rapid meanders would have been continued further on to the south-west. We find, on the contrary, that when the present river leaves the limestone, and passes on to the Trias, its course becomes less serpentine. Yet in its journey of half a mile over the Trias it falls only 25 feet. It follows from this that as the river cut its way down to lower levels, its course south-west of the limestone became less and less steep, and its flow less rapid. It ought, therefore, according to the known laws of river action, to have become *more* serpentine below the limestone. As the opposite effect has resulted, we are driven to conclude that there was something in the limestone itself, irrespective of the windings of the river on its Cretaceous or Jurassic surface, which determined the present zigzag shape of the glen.

Whether the river that formed the gorge originated on or in the limestone on the one hand, or on a higher Mesozoic surface on the other, appears to be not very material. In the latter case, it is to me incredible that the old curves should be maintained in a rock traversed by joints, many of which the solvent action of river-water must have quickly converted into fissures.

V.—On a new Trilobite from the *Dictyonema*-shales of the Malvern Hills.

By Professor Theodore T. Groom, M.A., D.Sc., F.G.S.

Acanthopleurella Grindrodi, gen. et sp. nov.

In the collection made by the late Dr. Grindrod, now in the Geological Museum at Oxford, there is a minute species of trilobite, represented by two specimens, obtained from the *Dictyonema*-shales of the Malverns. This form was referred by Dr. Callaway to *Shumardia* (*Conophrys*) *Salopiensis*, Call.;[1] but a careful study of the two specimens, aided by the removal of a small fragment of shale which partly concealed the more complete example, has shown the distinctness of the trilobite from *Shumardia*, and from any other genus known to the writer. Owing to the kindness of Professor Sollas I have been enabled to make a thorough examination of the specimens. The preservation is fairly good, but much of the actual test has been lost, and both fossils are largely in the form of internal casts. In the more complete but somewhat smaller example, which may be taken as the type-specimen, the whole trilobite is preserved (Fig. 3); in the second specimen little more than the thorax and pygidium is seen (Fig. 4). The following description refers to the type-specimen:—

Head smooth, semi-elliptical; frontal and lateral margins descending somewhat suddenly; genal angles acute. Glabella fairly convex, smooth, broad in front, reaching the margin (which here projects slightly beyond the cheeks), rather more than one-third of which it occupies; narrowing rapidly behind to the neck-furrow, behind which it expands again to form a well-pronounced and rather broad neck-lobe; separated from the smooth cheek by a deep and fairly broad axal furrow with a rounded floor; neck-furrow not strongly marked on the glabella, but well-pronounced on the free cheeks, to the posterior margin of which it is parallel; on the inner side it unites with the axal furrow, and on the outer extends nearly to the genal angle, and much resembles one of the pleural furrows; cheeks in front of the neck-furrow rising up steeply to their greatest height; no traces visible of other furrows on the glabella, or of eyes, or facial sutures on the cheeks. Length of head, 0·41 millimeter; breadth, 1·12 millimeter.

Thorax slightly narrower than the head, and longer than either head or pygidium; consisting of four segments. Axis very convex (Fig. 2), occupying some two-fifths of the width of the thorax in front, and gradually diminishing in breadth behind; inflated in each segment, the inflated portions being separated by rounded depressions, and extending to the pleuræ in the form of ridges directed obliquely forwards, one on each side. Pleuræ straight for most of their length, depressed near the axis (Fig. 2), especially in the first rings of the thorax, the depression gradually

[1] Quart. Journ. Geol. Soc., 1877, vol. xxxiii, p. 660.

dying out behind; each pleura facetted in front, and marked by fairly deep, straight grooves for the whole of their length, the grooves being margined in front by a well-defined ridge; at their ends the pleuræ suddenly bend sharply backwards and a little downwards, and end in spines; traces only of the first three pairs of spines are seen, but those of the fourth segment are long and extend for some distance behind the end of the pygidium. Length of the thorax, 0·54 millimeter; breadth, 1·08 millimeter.

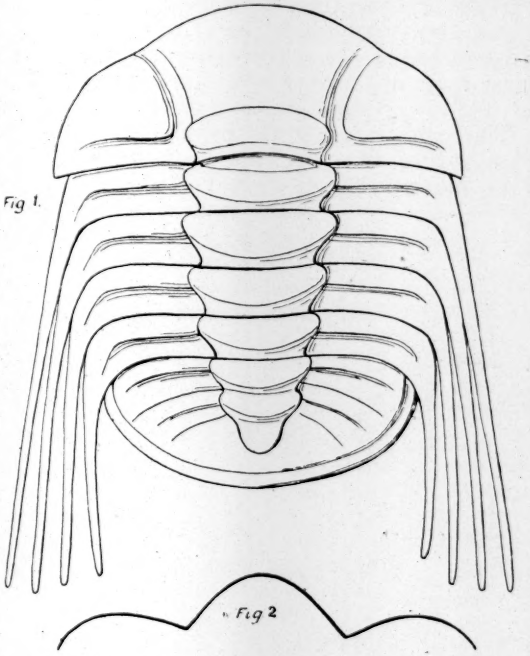


Fig. 1.—*Acanthopleurella Grindrodi*, gen. et sp. nov., restored with the aid of the specimens shown in Figs. 3 and 4. The spines at the ends of the pleuræ of the first three rings of the thorax require very careful illumination to render them visible.

Fig. 2.—Optical section of the tergum of the thorax of the specimen shown in Fig. 3.

Pygidium semi-elliptical; axis convex, conical, terminating at a short distance in front of the hind margin, and showing only one well-marked transverse constriction. Limbs tolerably flat, with several ridges and grooves corresponding to those of the thoracic pleuræ, and extending as far as the raised marginal rims. Margin probably entire. Anterior angles apparently rounded. Length of pygidium, about 0·4 millimeter; breadth, 0·83 millimeter.

The specimen is partly enrolled; this fact, together with its convexity, has made it impossible to obtain good photographs of the whole trilobite. The total length when unrolled would be 1·4 millimeter, or two-thirds of a line.

The second specimen (Fig. 4) belongs to an individual somewhat larger than the first. The length and breadth of the thorax are 0·62 and 1·1 millimeter respectively, and those of the pygidium 0·35 and 0·85 millimeter. The specimen, moreover, is less convex, perhaps partly owing to pressure, and the axis of the thorax is broader; in front it occupies nearly one-half of the total breadth of the thorax, and behind about one-third of the breadth at that point. The ridges connecting the axes with the pleuræ are, moreover, broader. Apart from these differences in proportion the two specimens agree, but the details of the thorax and pygidium are better shown in the second specimen. The spines of the first three thoracic rings are more perfectly shown, and those, at any rate, of the second and third extend backwards for a considerable distance. The pygidium shows more definite indications of a composition out of two segments in front, and an obscurely segmented or unsegmented portion behind; the rather narrow raised margin of the limbs is very distinct, and is entire. The anterior angles appear to be rounded. Of the head little more than a part of the neck-segment is preserved.

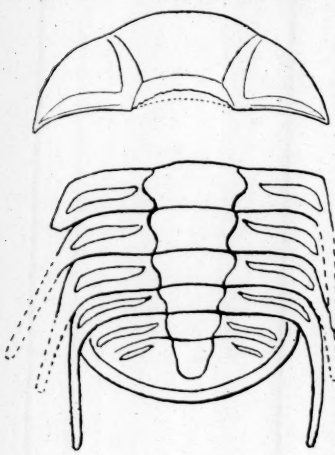


Fig. 3.

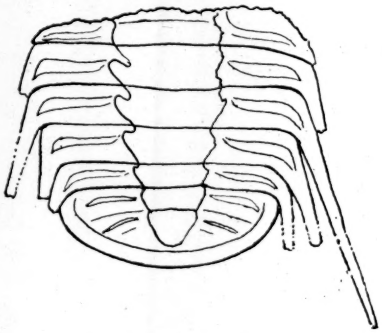


Fig. 4.

Fig. 3.—Head, thorax, and pygidium of *Acanthopleurella Grindrodi*, gen. et sp. nov., × 37, as made out with the aid of photographs and drawings. The specimen being partly enrolled, all three parts have been drawn separately.

Fig. 4.—Thorax, pygidium, and a portion of the head of *Acanthopleurella Grindrodi*, gen. et sp. nov. × 31. The outlines of this figure were traced from a photograph, with the exception of the portions defined by dotted lines, which have been made from freehand and camera lucida sketches.

Both specimens were obtained from the grey shales of the Southern Malverns, in which also *Cheirurus Frederici*, Salter, *Agnostus dux*, Call., and certain imperfect Asaphids and Olenids have been found. These probably include *Platypeltis Croftii*, Call., *Asaphellus affinis*, McCoy, *Niobe Homfrayi*, Salter, *Niobe*, sp., and *Parabolinella? triarthrus*, Call.

The affinities of this little trilobite are obscure. The diminutive size, the small number of segments, and the apparent absence of

eyes and facial sutures suggest that it may be a larval form. On the other hand, these features are also shown by such minute trilobites as *Agnostus*, *Microdiscus*, and *Shumardia*; and the lack of resemblance to any of the larger trilobites of the Tremadoc fauna, together with the circumstances that both specimens are minute, and that the larger of the two shows no advance in organization, tells in favour of the view that we are dealing with an adult form. For this form I would suggest the name of *Acanthopleurella Grindrodi*. The conformation of the head suggests Trinucleoid affinities, but there is no marginal rim, and the rest of the body appears to show Olenid characters. *Shumardia* is possibly an ally, but from this form *Acanthopleurella* differs in the extension of the glabella to the front margin of the head, in the absence of all glabella-furrows with the exception of the neck-furrow, and in the spinous prolongations of the thoracic pleuræ, and in other respects.

NOTICES OF MEMOIRS.

I.—On a Primitive Type of Structure in Calamites. By D. H. Scott, M.A., Ph.D., F.R.S.[1]

PALÆONTOLOGICAL research has afforded evidence that the Horsetails and Lycopods, groups now so distinct, had a common origin. The class Sphenophyllales, restricted, so far as we know, to the Palæozoic epoch, combines in an unmistakable manner the characters of Equisetales and Lycopodiales, while at the same time presenting peculiar features of its own. Broadly speaking, it is in the external morphology and in the reproductive structures that the Equisetales are approached, while the anatomy has an evidently Lycopodiaceous character.

The synthetic nature of the Sphenophyllales, indicated clearly enough in the type-genus *Sphenophyllum* itself, comes out still more obviously in the new genus *Cheirostrobus*. Here the general morphology of the strobilus, the form and structure of the sporangiophores and of the sporangia themselves, are all of a Calamarian type, while the anatomy of the axis is as clearly Lycopodiaceous in character.

So far nothing has been found to bridge the gulf which separates the anatomy of the Calamarieæ (Palæozoic Equisetales) from that of the Sphenophyllales or the Lycopods. The most ancient known genus of Calamarieæ—*Archæocalamites*—approaches the Sphenophyllales in the superposition of the foliar whorls and in the dichotomous subdivision of the leaves, points on which Professor Potonié, especially, has laid stress. Anatomically, however, according to the researches of Dr. Renault and Count Solms-Laubach, it was an ordinary Calamite, differing in no essential respect from those of the Coal-measures. The stem of *Archæocalamites*, like that of its later allies, had a large pith, surrounded by a ring of collateral vascular bundles, the wood of which, primary as well as secondary,

[1] Read before the British Association, Section C (Geology), Glasgow, Sept., 1901.

was wholly *centrifugal* in development, the first-formed tracheides lying on the border of the pith, at the points marked by the carinal canals. In *Sphenophyllum*, on the one hand, the whole of the primary wood was *centripetally* developed, and there was no pith. In *Cheirostrobus* the same holds good, except that an insignificant portion of the primary wood may possibly have been added in a centrifugal direction. In Lycopods there may or may not be a pith, but the whole (*Lycopodium, Psilotum, Lepidodendron*) or the greater part (*Tmesipteris*) of the primary wood is centripetal.

The Calamite which forms the subject of the present communication occurs in the well-known Burntisland beds of the Calciferous Sandstone Series, at the base of the Carboniferous formation. The material is calcified, and the structure excellently preserved, though the specimens so far discovered are small and fragmentary. Their interest depends on the fact that each vascular bundle possesses a distinct arc of centripetal wood on the side towards the pith. The carinal canals are present, as in an ordinary Calamite, and contain, as usual, the remains of the disorganized protoxylem. They do not, however, as in other Equisetales, form the inner limit of the wood, but xylem of a considerable thickness, and consisting of typical tracheides, extends into the pith on the inner side of the canal, which is thus completely enclosed by the wood. Hence, starting from the spiral tracheides of the protoxylem, there was here a considerable development of xylem in a centripetal as well as in a centrifugal direction. That the organ was a stem, and not a root, is proved, not only by the presence of the carinal canals, but by the occurrence of nodes, at which the outgoing leaf-traces are clearly seen.

This appears to be the first case of centripetal wood observed in a Calamarian stem, and thus serves to furnish a new link between the Palæozoic Equisetales and the Spenophyllales, and through them with the Lycopods.

The specimens have not as yet supplied any evidence as to the superposition or alternation of the verticils, so we are not at present in a position to determine the genus to which they belonged. Provisionally, until further investigation has cleared up this question, the new stem may bear the name of *Calamites pettycurensis*, from the locality where it occurs.

II.—The Scottish Ores of Copper in their Geological Relations.

By J. G. Goodchild, F.G.S.[1]

THE ores of copper occurring in Scotland appear, so far as their origin is concerned, to be referable to two primary categories. The first of these includes those minerals whose origin is evidently connected with the uprise of thermal waters; and the second includes those which are due almost entirely to deposition of materials carried down in solution from some rocks at a higher level to others below. The two methods of origin may be likened to the ebb and the flow of the tides.

[1] Read before the British Association, Section C (Geology), Glasgow, Sept., 1901.

To the first category belongs most of the Chalcopyrites occurring in Scotland, and with that mineral is to be included also Chalcocite and Bornite. These mostly occur in connection with mineral veins. A small percentage of other compounds of Copper with Sulphur appears to have originated in connection with certain eruptive rock of sub-basic composition. When these latter have been affected by dynamic metamorphism the process seems to have favoured the local concentration of the mineral which was formerly diffused. Hence several Epidiorites contain Chalcopyrites, apparently as an original constituent (if we regard their schistosity as original to that type of rock).

To the second category, that of the ebb-products, or minerals of secondary origin, belong all the remainder.

Taking these in the order, and with the numbers, adopted by Dana, we have, first, (15) Native Copper. There cannot be much doubt that all the Scottish specimens of this are of secondary origin. The earlier stage seems to have been that of solution, along with those of the constituents of a sub-basic eruptive rock, through which, probably, the copper ore was originally diffused in very minute quantities. The decomposition of the rock by surface agencies has again converted this into solution—probably in the form of carbonate—from which solution any one of various reagents, in most cases probably decomposing organic matter, has reduced the dissolved substance to the metallic state. In this form it has been deposited as thin sheets along the divisional planes of the rocks situated at a lower level than its point of origin. In the form of films of this kind it occurs at Boyleston, in Renfrewshire, where it is found in lavas of Lower Carboniferous age; and at Ballochmyle, in the joints traversing the marls of the New Red Rocks there. I may remark, in passing, that these rocks so closely resemble the Bunter Sandstone that I should never have hesitated to refer them to that horizon had not a different opinion regarding their age been expressed by the distinguished author of "The Scenery of Scotland."

Native Copper also occurs in the form of minute particles—possibly crystals—in some of the Prehnites of Boyleston and Glen Farg. Doubtless these varieties of Prehnite owe their colouring matter to the presence of this mineral, just as the ordinary green variety of Prehnite owes its colour to diffused compounds of copper of other kinds—possibly to Chrysocolla. The same metal also occurs at Boyleston, disseminated throughout some of the beautiful crystals of Calcite which line some of the drusy cavities of the lavas there. When Native Copper is enclosed in these crystals the external form is much more complex than where the metal is absent.

Some Chalcopyrites must undoubtedly be classed amongst ebb-products also, seeing that a second generation of crystals often occurs upon minerals whose secondary origin cannot be doubted. Atacamite has been claimed as a Scottish mineral, but, it seems to me, on insufficient grounds.

(224) Cuprite, as might be expected, occurs in connection with the other decomposition products of common ores. Usually it occurs

as one of the constituents in the compound known as Tile Ore; but occasionally, as at Glen Farg, it shows traces of crystalline exterior; or as at Boyleston, where Mr. Craig-Christie has got it in the capillary or velvet-like form. Some of the silicate of copper from Lauchentyre appears to me to be coloured red by Cuprite, which may also occur there in the free state.

(230) Tenorite has not yet been proved to occur as a separate Scottish mineral; but the black Chrysocolla from Lauchentyre and other mines in the neighbourhood may possibly owe its coloration to this mineral.

(288) Malachite calls for no special remark here beyond the statement that it does not appear to show crystalline termination at any locality in Scotland except at Sandlodge, in Shetland, where it seems to have been taken for Brochantite.

(289) Azurite is singularly rare in Scotland, and has not yet been found with visible crystalline faces. (290) Aurichalcite, (741) Linarite, and (739) Caledonite, well known as secondary products of the decomposition of veins containing Copper, do not call for any special remark in this abstract.

REVIEWS.

I.—Roads: their Construction and Maintenance; with Special Reference to Road Materials. By Allan Greenwell, Assoc. M. Inst. C. E., F.G.S., and J. V. Elsden, B.Sc., F.G.S. 8vo; pp. 280. (London: *The Builder* Student's Series. Price 5*s*.)

GEOLOGISTS may well claim to have an interest in road-metal. The heaps of stone by the roadside arrested the attention of the 'naturalists' in old days, and ofttimes attracted them to the quarries. Thus the Kellaways Rock of Wiltshire came into notice and attained a distinction which nowadays would not have been accorded to it. Then each parish, whenever possible, provided material for its roads, and in different parts of the country there were numberless pits and quarries, many of which have long since been closed and hidden beneath soil and vegetation. Even now many by-roads are mended with local stone of no great durability, and in parts of Somerset these ways are repaired with the basement limestones and fossils of the Upper Lias. Along the principal roads the freestones and rag-beds of the Oolites, however, are less frequently used; the Carboniferous Limestone, the Hartshill stone, and the dark basalts of Clee Hill and Rowley Regis have usurped their place. Far better roads have resulted, although carriers have complained that they cannot see their way at night so readily as of yore on the present dark metal. To the introduction of railways we may trace the dispersal of the better kinds of road material, while, as the authors remark in the work before us, the powers acquired by County and District Councils "have completely revolutionised the system of road management in this country."

Arranging their subject under three heads—(1) Materials, (2) Construction, and (3) Maintenance—the authors in the first part deal with the selection of road material, and point out the various kinds of rock that have been used, and their geological distribution. Figures of micro-sections are given to make clear the mineral structure of various kinds of stone; while their texture and absorptive power and the joints in the rocks are duly explained. Special tables are given of the principal constituents of some igneous rocks used as road stone.

The value of particular stones as paving setts is pointed out, and it is observed that some igneous rocks wear to a smooth and slippery surface. Following the igneous rocks, the sandstones, limestones, flint and chert, and gravel are successively dealt with. There are also chapters on artificial materials, including slag, which is extensively used in some neighbourhoods, though it yields an offensive odour and is unsuitable for residential areas. Among paving materials, wood and asphalt are included.

Tables showing results of various tests are given in reference to some of the principal rocks, and in the 'percussion test' we note that the greenstone of Penzance withstood the greatest number of blows. This is evidently the well-known Penlee stone, which is elsewhere referred to under that name, and also as Newlyn stone. After considering various tests of strength it is well observed that the test of experience is the best; but this is not always forthcoming.

In the second part of their work the authors give a brief historical account of roads from Roman and mediæval times to the days of Macadam and Telford. A knowledge of geology is of essential service in the laying out and construction of roads. Cyclists in particular are shrewd observers of roads, and with a knowledge of geology they may, as Mr. F. J. Bennett has pointed out, learn much from the gradients, the springs, and the character of the surface formed by the road-metal.[1] The very diversity is interesting, and we should not wish to see Telford's rule adopted that "It is absolutely necessary to remove trees from the sides of roads, and to keep the fences under five feet in height."

The authors give numerous illustrations, some geological, to aid in their explanations of road-making. Indeed, in this and other respects the accumulated knowledge of the engineer and the practical geologist is happily combined in this volume. Thus the work, though professedly of an elementary nature, should prove most useful to local road-surveyors and to others called upon to find or advise in selecting road material.

A fuller index than the authors have given would be desirable in a new edition; thus, Crushing strength, Cobbles, Mountain Limestone, Oolite, Forest Marble, Greywethers, and a few other subjects referred to in the text, should have been found. Mention is made of certain tests of rocks carried out in Maryland, and the reference might have been given to the third volume recently

[1] "Influence of Geology on the Early Settlements and Roads": Proc. Geol. Assoc., vol. x, p. 377.

published by the Maryland Geological Survey, which contains an exhaustive account of the highways, their history, relations to topography, climate, geology, and various other matters, and is a handsomely illustrated volume.

H. B. W.

II.—The Riddle of the Universe at the Close of the Nineteenth Century. By Ernst Haeckel, Ph.D., M.D., LL.D., Sc.D., Professor at the University at Jena. 2nd edition; pp. 398. Translated by J. McCabe. (London: Watts & Co. Issued by the Rationalist Press Association, Ltd., 1901.)

IN "Die Welt-räthsel," most ably translated by Mr. J. McCabe, Professor Haeckel presents the "continuation, confirmation, and integration" of his views on the monistic philosophy already expressed in previous volumes and in a paper read at the Fourth International Congress of Zoology at Cambridge in 1898. He claims that, after working at it for half a century, his system is now mature, and offers a full explanation of the phenomena of nature, as well as a solution of the "conflict between Science and Religion"—in short, that it solves the "Riddle of the Universe."

He argues that, while our scientists have made, during the past century, extraordinary progress in the unravelling of the mysteries of the universe, they have been too much bound down by specialism, and have not sufficiently studied the universal connection of the phenomena they observe. In consequence of this, advantage has not been taken of our increased knowledge, and no corresponding improvement is to be observed in our systems of government, of administrative justice, of national education whether in the school or from the pulpit, of social and moral organization. We may congratulate ourselves that here, in Britain, we are exempt from at least some of the defects mentioned by Professor Haeckel under these headings.

The author's solution of the difficulty is that a change should be made in the present system of education. The study of nature, combined with the elements of evolutionary science, should take the first place. Let the child be taught a correct view of the world he lives in, and be given an insight into the natural connection of all phenomena, as, indeed, Huxley advocated in his science of physiography. Let him understand that reason alone, itself the result of the development of knowledge, can unravel the mysteries of life, and that no cosmic problem can ever be solved by emotion. This development of the use of reason by education and experience would, the Professor thinks, lead to the universal adoption of 'Monism' as the true solvent of all cosmical and religious difficulties.

Monism, in its widest sense, recognizes one sole law in the universe, the *Law of Substance*, which embraces conservation of matter and conservation of energy. The monist holds that the universe is at once "God and Nature," and, with Spinoza, that

body and spirit (or matter and energy) are inseparable. Sensitive and thinking substance are the two fundamental attributes of the all-embracing divine essence of the world, the universal substance. Opposed to Monism is Dualism, which, in its widest sense, breaks up the universe into two entirely distinct substances—the material world, and an immaterial, extramundane God. Dualism necessarily leads to Theism, in some form. Monism, on the other hand, leads to Pantheism, which teaches that God is everywhere identical with Nature itself.

Whether or not we adopt Professor Haeckel's views on religious matters, the book is well worth reading as a resumé of the progress of the various branches of scientific knowledge to the end of the nineteenth century, and particularly, as we should expect from the author, of biology. The subject of the "conflict between Science and Religion" holds a conspicuous place in the argument. It has already been well handled by Strauss, Feuerbach, and Draper, to whom Haeckel refers his readers. For geologists, the best account of the part which geology has played in the controversy is that given in the magnificent work of Mr. A. D. White, who points out that the contest is *not* between Science and Religion, but between Science and dogmatic theology, of whatever kind.

J. A. W.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I. — December 18th, 1901. — J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair.

Professor H. G. Seeley drew attention to a skull of *Equus fossilis* from Keswick, exhibited by Mr. J. Postlethwaite, F.G.S., and said that it belonged to a species of horse, but the skull appeared to be broader and flatter in front of the orbits than in *Equus caballus*; and it gave evidence on the upper surface of being an aged specimen, an inference which was supported by the palatal conditions. The teeth are worn down, so as to approximate to the condition of aged teeth of *Equus fossilis*, as sometimes met with in river-valley gravels; but he was not aware that these teeth had previously been met with in association with this form of skull. He understood that the specimen had been found near the surface beneath an ancient building at Keswick, and that there was no evidence as to its geological antiquity.

Professor W. W. Watts called attention to a set of twenty-two photographs, the first of three sets to be published as typical examples of geological photographs by the Committee of the British Association on Geological Photographs.

The following communications were read :—

1. "Coal and Petroleum Deposits in European Turkey." By Lieut.-Colonel Thomas English, F.G.S.

In this paper an account is given of the formations which include some recently discovered coal-seams and naphtha-bearing sands of Tertiary age in the little visited stretch of country lying to the north of the Gulf of Xeros in the Mediterranean, and of the western portion of the Sea of Marmora. The geological map which accompanies the paper is founded on the topography of that compiled by the Russian military staff. The lowest beds seen are soft brown limestones, with nummulites of Lutetian age, overlain by blue shales. These, again, are covered conformably by brownish-grey calcareous sandstones, with subordinate beds of clay and shale, and occasional interruptions of basalt and rhyolite, which are folded into a well-marked syncline and anticline. In these sandstones there are outcrops of several seams of coal, one being $3\frac{1}{2}$ feet thick. It is a bituminous, hard, non-coking steam-coal, with a sandstone floor and hard clay-roof containing impressions of dicotyledonous leaves. Associated with the coal is a layer of brecciated rhyolite, which may have had some influence in converting lignite into true coal. The section of a trial boring, striking the coal at 122 feet from the surface, is given; and also that of a boring 225 feet deep immediately below the coal. Apparently overlying the sandstones are palagonite-tuffs, shales, and hard limestones of Miocene age. The Eocene sandstones are occasionally overlain by soft sandy strata, probably Pliocene, with which naphtha-bearing beds are interstratified. Naphtha in quantity, under considerable gas-pressure, has been obtained from borings, a section of one of which is given, 300 feet deep. The strata are much disturbed and are nearly vertical in places. A stony clay, having no apparent connection with the present drainage system, and containing scratched, striated, and facetted boulders, spreads unconformably over all the formations previously mentioned. At the Hora lighthouse a well-marked 'raised beach' occurs at 130 feet above present sea-level, sometimes cemented into a concrete, in which occur *Dreissena polymorpha* and a *Neritina*, probably *N. danubialis*. The fresh water within the Sea of Marmora must at this epoch have stood at a height sufficient to collect the drainage of the whole of South-Eastern Europe and Western Asia, an area of at least 2,000,000 square miles, into a fresh-water sea, from which the volume of water discharged (even with the present small rainfall) would be not less than twice that of Niagara. The Dardanelles channel is itself a gorge cut back through soft horizontal Miocene strata, with every appearance of rapid erosion by falling water.

2. "On the Geological and Physical Development of Dominica; with Notes on Martinique, St. Lucia, St. Vincent, and the Grenadines." By Professor J. W. W. Spencer, Ph.D., M.A., F.G.S.

These islands form a continuation of the volcanic chain extending from Guadeloupe, though separated one from the other by embayments in the submarine plateau, reaching to depths of more than 6,000 feet, within the line connecting the shores of the islands. These submarine valleys head in cirques, like the amphitheatres which

occur on the slopes descending from high plateaux. From the ends of the cirques, valley-like channels can be traced landward on the submerged plateaux, or can be found to cross them in order to join like features on the other side. The cols between the opposite valleys vary in depth from about 2,000 to 3,600 feet, except that between the Grenadines and the Trinidad banks, where the divide may not be more than 750 feet below the surface of the sea, and one south of St. Vincent (less than 1,300 feet). Some of the submarine channels have remarkable tributaries. The drowned valleys, like those about the islands to the north, assume two very different forms—those with broad undulating outlines, such as characterize the features produced during the long Miocene-Pliocene period of erosion, when the surfaces of the land were at or near the base-level of erosion, and other types where very deep valleys and gorges incise the more rounded features of the drowned plateau, which in the early Pleistocene epoch thus appears to have stood for a limited time at an altitude of 6,000 or 7,000 feet, as shown within the limits of the Antillean mass (and still higher from evidence beyond). There are no coastal plains, strictly speaking; only to a very limited extent are the islands surrounded by shelves submerged to a depth of less than 200 feet. But the Grenadine banks are extensive. One or two outlying remnants of the Antillean plateau occur south-east of Dominica, and another about 60 miles east of Martinique, all of which may be fragments of the old coastal plains.

All the islands are underlaid by old Tertiary or pre-Tertiary igneous rocks, as in Guadeloupe. Such, where exposed, are found to be very much decayed. Elsewhere, they are covered by tuffs with only angular breccia. Upon such surfaces, denuded, rest other tuffs derived from older deposits, containing water-worn pebbles, in lines of bedding. These last may be the equivalent of the Tertiary tuffs and limestones of Guadeloupe. Upon their eroded surface rests a gravel formation, which itself has largely been washed away. In the hollows of its surface is found another formation composed of coral limestone, containing a fauna which still survives, with one or two possibly extinct forms. The deposit occupies a position similar to one in Guadeloupe and another in St. Kitts. Its surface is also greatly eroded, and then covered with another stratified sand-and-gravel accumulation. The surface of the slopes is often covered by a loam, which, in part at least, is a land-formation. The Pleistocene Period is thus seen to have been one of changing physical conditions. The older Tertiary history must be inferred from that of the neighbouring islands.

Lavas may be seen underlying the gravels, and accordingly we find that the volcanic activity was renewed, after a very long Tertiary quiescence, in the Pleistocene Period.

The plains underlaid by the beds of old tuffs have been so raised up as to give rise to sloping terraces dipping outward from the late volcanic centres, showing that their elevation has been due to local uplifts, and not to regional movements, and also that to igneous centres alone are confined the volcanic uplifts, which do not extend

to such remnants of coastal plains as are found in the Antillean region. The recent terraces, which are not deformed, are small, and perhaps do not rise to more than 70 feet above the sea. Youthful cañons are being formed near the mouths of the streams, showing the recent re-elevation of the land.

3. "On the Geological and Physical Development of Barbados, with Notes on Trinidad." By Professor J. W. W. Spencer, Ph.D., M.A., F.G.S.

Barbados, over 100 miles east of the main chain of islands, is a remnant of the dismembered and sunken Antillean plateau, with the embayment in it, west of the islands, reaching to a depth of over 7,000 feet. But the drowned Barbados ridge extends far, both to the south and to the north of the island, and is connected by another ridge with the Martinique mass. Its hydrographic features are best understood when studying the question of the general relationship of the islands.

Trinidad is part of the South American continent, being on the subcoastal shelf which extends much farther seaward.

The Scotland Sands and the deep Oceanic Series of Barbados have been comprehensively studied by others. The Oceanic Series is here shown to be no newer than the Eocene Period, and the Scotland Series is supposed to date back to the beginning of the Tertiary or even to an older epoch. The 'Raised Coral-Reefs' are differentiated into three formations, all of white limestone or marl. The oldest beds are all tilted to considerable angles. They contain an Oligocene fauna. Their surfaces are eroded into rounded forms, showing that the topographic feature was completed at a low elevation above the base-level of erosion. As no other Tertiary formation occurs until the close of the Pliocene, it is inferred that the region was a land-surface throughout the long Miocene-Pliocene Period. This limestone is the equivalent of the Antigua formation. In the hollows of its surface occur the remains of a mechanical limestone (the Ragged Point Series), which has been mostly carried away by subsequent denudation. It lies in a horizontal position. Newer still is the Bath Series, or raised coral-reefs, with a fauna still living. However, it is an old Pleistocene formation, and its surface is very much denuded. Some of the newer fossiliferous beds may represent even another distinct Pleistocene epoch. The greatest elevation and denudation appear to have been in the early Pleistocene days. The terraces occur in Barbados at much higher elevations than in the other islands, as this district does not appear to have undergone so great an amount of recent subsidence as that which carried down the surfaces, with little cañons and channels, below sea-level, adjacent to the other islands. The local features of Barbados extend our knowledge of the history of the whole chain of islands, besides agreeing with the phenomena found elsewhere.

Trinidad has more continental features than the other islands. Its surface topography has been found to owe its origin to the

erosion features of the Miocene-Pliocene Period, which have been covered by only thin mantles as in Barbados, so that its life-history falls into harmony with that of the other islands. In its older beds it has the deep oceanic oozes as in Barbados. No volcanic phenomena have been added to the features of these islands.

II.—January 8th, 1902.—J. J. H. Teall, Esq., M.A., F.R.S., President, in the Chair. The following communications were read:—

1. "A System of Glacier-Lakes in the Cleveland Hills." By Percy F. Kendall, Esq., F.G.S., Lecturer in Geology at the Yorkshire College, Leeds.

After referring to existing 'extra-morainic' lakes, such as the Märjelen See and those of the Chaix Hills, the author proceeds to deal with the criteria for the recognition of such lakes. These include beaches, deltas, floor-deposits, and overflow-channels. Shore-scarps are common in Cleveland, but beaches are rare or absent, the reason being in part that stability was rarely secured owing to the overflows being over soft Jurassic strata. Deltas also are not common. The floor-deposit of lakes may be distinguished from river-alluvia by the fact that the lamination is close and regular, but, being parallel to the subjacent surface, it may be highly inclined. On the other hand, alluvia are laid down on horizontal surfaces, but rarely show good lamination. Overflow-channels are grouped into four main types: 'direct overflows,' which trench the main watershed of a country; 'severed spurs,' across the spurs of the main watershed; 'marginal overflows,' at first merely a shelf cut in the hillside, but subsequently developed into an actual gorge; and 'in-and-out channels,' or crescentic valleys excavated in the face of a hill by water flowing round a lobe of ice. Such overflows are independent of the natural drainage; they have at first a slight and then a steep fall, and in section they have steep sides and flat floors. The meanders of the valleys and the run of the contouring also possess special features, and the valleys rarely or never receive any considerable tributaries.

Evidence from borings and drift-filled channels is given to show that during or before the Glacial Period the land was considerably above its present level. The Glacial deposits are described in detail from sections and borings, some of them carried out by the author, and the assemblages of boulders are identified and classified into three chief groups—a Western group, from the Solway, Vale of Eden, Stainmoor Pass, and the Tees; a Northern group, from the Tweed and Cheviots and from Eastern Durham; and an Eastern group, from the Christiania region, the Gulf of Bothnia, and Denmark or the North Sea.

The author has been unable to detect any signs of the presence of the sea in this area at any time during the Glacial Period. Three main ice-masses appear to have been concerned in producing the deposits: one from the Southern Uplands and the Solway, joined by the local ice of the Tees; a second originating in the

Tweed Valley, and driven southward round the Cheviots by the pressure of the third, or Scandinavian, ice-mass. The general order of events is supposed to have been—(1) the unobstructed passage of the Teesdale glacier to the coast; (2) the arrival of the Scandinavian ice; and (3) the invasion of the Scottish ice.

The first of the extra-morainic lakes described is that of the Vale of Pickering, the lowest of the sequence, which for a long period received all the drainage of the district except that of the western margin, and the outflow from which into Lake Humber was that now occupied by the River Derwent. Newton Dale was the outflow of the lake-series of the Eskdale country. The Eskdale system comprises a series of lakes connected by an 'aligned sequence' of overflows; and here it is possible to trace the consequences of the shrinkage of the ice-masses and to follow out the low-level phases of the lake. The ice pressing upon the northern face of the Cleveland Hills gave rise to a series of lakelets, connected with which are the following set of overflows:—Scugdale and Scarth Nick, Bilsdale, Kildale, Ewe Crag Beck, Tranmire, and Egton Moor. Iburndale contained a lakelet overflowing eastward. Behind a narrow coast-strip of country, extending from Robin Hood's Bay to Hunmanby, there runs a gorge which receives all the drainage of the 'hinterland' and carries it into the Vale of Pickering. In the production of this arrangement the effects of an ice-sheet shutting the seaward ends of the valleys is traceable; the position of the main overflows was stable, and the drainage was permanently deflected.

In dealing with the sequence of the ice-movements, evidence is brought forward to prove that the Teesdale ice was the first on the ground in question, but none of the lake phenomena have been correlated with this first phase. The second phase was the complete diversion of this ice into the Vale of York, brought about by the growth of the Scandinavian ice-sheet. The third is the invasion of Scottish-Northumbrian ice, which may have passed out to sea and been driven inland again, carrying flints and smashed sea-shells with it, and may have extended as far as Lincolnshire on the south and Whorlton on the west.

2. "The Glaciation of Teesdale, Weardale, and the Tyne Valley, and their Tributary Valleys." By Arthur R. Dwerryhouse, Esq., B.Sc., F.G.S.

After an account of the topographical solid geology of Teesdale, the author describes the four distinct types of Drift in the area as follows:—

(*a*) A sandy reddish-brown clay, with a large number of well-scratched stones.
(*b*) A black loamy or peaty clay.
(*c*) A coarse gravelly deposit, with many water-worn and a few scratched stones.
(*d*) A stiff blue Boulder-clay.

The first class is the most widely distributed; it occurs in elongated ridges, and is the direct product of ice-action on the rocks of the upper part of the Dale. The black loamy clay is characteristic of areas occupied by ice-dammed lakes. The third class occurs in long esker-like ridges, and is particularly plentiful in the country

formerly occupied by the Stainmoor glacier. The dark-blue clay is mainly derived from Carboniferous rocks. A detailed description of the Glacial deposits, boulders, and striæ is next given; and from this the following conclusions are deduced:—Upper Teesdale was heavily glaciated by local ice from the eastern slope of the Cross Fell Range; this part of the Dale was not invaded by any other ice, and the higher peaks stood out as nunataks. At the period of maximum glaciation a number of lakes were formed, owing to the obstruction of the drainage of lateral tributary valleys by the ice of the main glaciers. Lunedale was occupied by ice (the Stainmoor glacier) which came from the drainage-basin of the Irish Sea, joined the Teesdale glacier about Middleton-in-Teesdale, and by its thrust deflected the Teesdale ice into the Valley of the Wear. During the retreat of the ice there was a lengthened period of 'constant-level,' when well-marked drainage-channels were formed, and after this the ice was removed with great rapidity. A tongue of ice flowed from Upper Teesdale by Yad Moss to the Valley of the South Tyne.

Similar evidence with regard to Weardale and the Tyne Valley is given, and the following conclusions are drawn among others:—Ice from Teesdale and the tributaries of the South Tyne occupied the valley of the latter nearly as far as Lambley, where it was joined by a large glacier which crossed the northern end of the Pennine Chain. This glacier was continuous in a northerly direction with the ice of the Southern Uplands and the glacier of the North Tyne, and, when at its maximum, deflected the last north-eastward, causing a movement in that direction along the southern flanks of the Cheviot Range. But at the beginning and end of the glaciation the ice in the Valley of the North Tyne flowed south-eastward. The southern margin of the South Tyne glacier passed across the heads of Allendale and Devil's Water into the Wear Valley; and along this margin were a series of ice-dammed lakes with a corresponding series of overflow-channels, many of which are now streamless. Weardale was mainly occupied by its own ice, but the lower part of the valley was invaded by the Tyne ice from the north and that of the Tees from the south. There were no lakes strictly connected with the last system.

CORRESPONDENCE.

DEAN BUCKLAND AND McENERY.

Sir,—May I call attention to a point in the history of geological science which seems in danger of falling into the realm of myth, and which apparently can yet have light thrown on it by at least two geologists, whose names are well known and honoured by all who desire that that history should be handed down to future generations in its integrity. I refer to Professor Rupert Jones and Mr. A. R. Hunt.

The first discoveries which led to the views now held as to the antiquity of man were made in Kent's Cavern in 1825–6 by the

Rev. John McEnery. Yet English science has lost the credit of priority by the fact that the records of these discoveries remained unpublished until 1859. It has been suggested that their publication was "suppressed," owing, according to one writer, to the influence of Huxley, of all men in the world. The erroneousness of this amazing statement was at once pointed out by the two geologists I have named. Mr. Hunt, however, associates the delay in the publication of the Kent's Cavern evidence with the delay in issuing that of the Brixham Cave. The two cases seem entirely distinct. McEnery's discoveries were made thirty years before the Brixham Cave was explored, and during that time many facts discovered on the Continent had come to light. Professor Rupert Jones, on the other hand, tells us that the notes, supposed to be "lost," were "really kept in the background by influence of the Rev. Dean Buckland." The Professor must be in possession of facts which are certainly not to be found in the evidence as it stands.

I have carefully studied the literature of the subject, and can find no suggestion of influence brought to bear by anyone with a view to suppression of publication of the notes. McEnery *may* have been deterred by fear of orthodox persecution, or out of deference to Dean Buckland, who differed from him in some of his conclusions, but there is no evidence for either theory. If I might suggest a reason for the non-appearance of the work during his lifetime, I should say it is to be found in the modesty, simplicity, and amiability of McEnery's character. His own story is perfectly explicit. His original intention was to publish the results of his researches at once. His private means being insufficient for this, he drew up a prospectus with the object of procuring pecuniary assistance, but apparently this prospectus was never issued. Partly on account of bad health, and partly in the belief that some one better equipped than himself in geology and palæontology would take the matter up, he abandoned the idea of publication, but continued adding to and altering his notes to such an extent that they became terribly confused. We find additions made to them as late as 1836, containing quotations from Buckland's Bridgewater Treatise, published in that year. Finally, shortly before his death, he again announced his intention of publishing his memoir forthwith. Unfortunately, he died in the beginning of 1841, without having even prepared his notes for the printer.

The subsequent history of his manuscript seems equally clear. His effects were sold by auction, and the precious notes happened to be mixed up in a miscellaneous 'lot' of sermons and other papers, which was purchased by Mr. Lear, a Torquay tradesman who collected fossils. From him, or perhaps after his death, they were purchased by Mr. W. Long, F.G.S., of Saxmundham. This gentleman had already shown much interest in cavern researches, and had communicated a paper on the subject to the British Association Meeting at Newcastle in 1838. He handed them over to Mr. Vivian with a view to their publication, which was effected in 1859. It is worthy of remark that for seven or eight years

before that date, any influence on the part of Dean Buckland was out of the question. Professor Rupert Jones has, rightly, I think, referred to the statement regarding Huxley as "not only uncalled for, but unkind." Will he now, for the sake of historical accuracy, give us his reasons for placing the burden of responsibility on the shoulders of the Dean? And will Mr. Hunt let us have the "long story" so far as it refers to McEnery's notes? If, as he says, it dates "long subsequent to McEnery's death," again it is difficult to see where and how Dean Buckland's influence was exerted.

J. Adam Watson.

"Hay Tor," Dennington Park Road, Hampstead.
December 21st, 1901.

THE HOLOCENE DEPOSIT AT CASTLE CARY.

Sir,—In our recent paper on "The Post-Pliocene Non-Marine Mollusca of the South of England" (Proc. Geol. Assoc., vol. xvii, pt. 5), when speaking of the holocene deposit at Castle Cary (p. 234) we express regret that we were unable to obtain any information concerning it.

Our attention has now been called to the fact that an account of this alluvial deposit is given in the Geological Survey Memoir on East Somerset by Mr. H. B. Woodward, and we hasten to express our regrets to that author for the oversight. He gives the following list of shells which he obtained from the spot in 1868, viz.: "*Helix aspersa, H. nemoralis, Cyclas, Ancylus fluviatilis, Limneus, Unio* (fragments)." Of these, only one, the *Ancylus fluviatilis*, is common to our list; concerning the others, not having seen the specimens, we are unable to pronounce any opinion.

A. S. Kennard.
B. B. Woodward.

OBITUARY.

PROFESSOR RALPH TATE, F.L.S., F.G.S.

Born 1840. Died September 20, 1901.

If Professor Tate had remained in England his loss would have been severely felt by British geologists; as it is, that loss is to a large extent transferred to the Antipodes, where South Australia will increasingly lament the departure of one who has been so much to the science of the Colony. In this country his memory will linger chiefly in the minds of those who can look back beyond the last quarter of a century, but it will be a fond memory, based on sincere admiration of his powers and his character.

Ralph Tate was the nephew of the well-known geologist George Tate of Alnwick, where he was born in 1840. He received his primary education at the Cheltenham Training College, whence he was sent in 1857 to the Royal School of Mines, where he studied for two years. After some little practice in teaching at the Polytechnic he went to Belfast in 1861 as teacher of Natural Science

at the Philosophical Institution, his principal subjects of interest being Botany, non-marine Conchology, and Geology, particularly the palæontological side of it. His first proceeding was to found the Belfast Naturalists Field Club, which is still in vigorous operation, and he also drew up a Flora of Belfast and, at a later date, a descriptive list of Irish Liassic Fossils, including several new species. An earlier paper on an allied subject contributed in 1864 to the Geological Society was followed by his removal to London as Assistant-Curator to the Society, the results of which appointment may be seen in the admirable condition as to naming, etc., of the specimens in the Society's Museum which came under his hand. Whilst in this position he contributed three papers to the Quarterly Journal—on the Cretaceous Rocks of the North-East of Ireland, on the Zone of *Ammonites angulatus*, and on the South African Fossils in the Museum—all highly palæontological. He was also at work in the other branches of Natural History which interested him, writing three Botanical papers in 1866 and a small textbook on Land and Fresh-water Mollusca. These various branches were so well handled that Lyell and Huxley amongst geologists, Gwyn Jeffreys amongst conchologists, and Hooker, Baker, and Carruthers amongst botanists nominated him as Associate of the Linnean Society in 1866.

In 1867 he was sent by the Central America Association on an exploring expedition to Nicaragua, and in the following year to Guyana in Venezuela, expeditions which resulted in papers to the Geological Society on the geology, and to the American Journal of Conchology on the non-marine Mollusca of those countries. In the interval and afterwards he conducted classes at the Mining School at Bristol, and also brought out his well-known Appendix to Woodward's Manual of Mollusca, and an admirable little class-book of geology forming two volumes of Weale's Rudimentary Series; at the same time he was communicating a series of Jurassic papers (four) to the Geological Society. In 1871 he was appointed teacher to the Mining School established by the Cleveland Ironmasters, first at Darlington and then at Redcar. His attention was thus drawn to Yorkshire, and ultimately led to his bringing out (in conjunction with the writer of this notice) his well-known work "The Yorkshire Lias."

About this time, however (1875), a complete change occurred in his life on his appointment as Professor of Natural Science on the Elder Foundation at the University of South Australia in Adelaide. To the work thus opened before him he henceforth devoted all his energies. He found there a Philosophical Society issuing no proceedings and studying science chiefly at second-hand. This Society he determined to raise to a high position by commencing a series of Transactions, and publishing in them his papers on the Geology and Natural History of the Colony, instead of sending them to better known and more widely circulating journals, and by persuading others to do the same. For three years he piloted this Society, first as Vice-President and constant Chairman (1877–8),

and then as President (1878–80), by which time he had established it under the new title "The Royal Society of South Australia." In the twenty-four volumes issued up till now we find no less than ninety-one papers contributed by him: a few of these are botanical, others are on general geology, such as glaciation, but the greater number are on the Tertiary beds of the continent and their fossil Mollusca. On this subject he contributed also to the Proceedings of the Royal Society of Tasmania, of the Linnean Society of New South Wales, and of the Australian Association for the Advancement of Science, of which he was President in 1893. How broadly and firmly he thus laid the foundation of our knowledge of Molluscan phylogeny in the Australian province may be judged from a Catalogue of Tertiary Australian Mollusca in the British Museum issued in 1897. Out of 380 species therein recognized from the Australian continent, 225 are species established by him and 90 more are determined or recorded in his writings; every one of his species (with a single doubtful exception) is accepted by the author of that catalogue, and only four corrections of names are suggested. This is probably a 'record' result.

In 1888 Professor Tate took over the editorship of the Transactions, and with one short intermission continued it to the last. In 1893–5 he was again President as 'Governor's Representative,' and he took occasion to congratulate the Society on the position its Transactions had attained, and to thank the early contributors for their self-sacrifice for its sake in sending their papers to a publication then so obscure. Soon afterwards he learnt the price he had himself paid in doing the same. In the Autumn of 1896–7 he paid a visit to this country, and unhappily the opportunity was not seized of giving him that recognition of the value of his work which undoubtedly would have long ago been his had he remained in this country or sent his papers to European publications. He was somewhat disappointed at this, but let us hope he was a philosopher. At all events, he continued his work in his adopted country with undiminished zeal, and only the approach of his final malady put a period to his activity. Early this year heart trouble gradually became more serious, and brought his useful and honourable life to a conclusion on September 20th. He was twice married, and leaves behind him several children all well established in life, as is his own reputation in the minds of all palæontologists.

J. F. B.

List of the scientific papers by Professor Ralph Tate, F.L.S., F.G.S., deceased, late of Adelaide University, South Australia:—

"Flora Belfastiensis," 8vo, Belfast, 1863, pp. 92.

"On the Liassic Strata of the Neighbourhood of Belfast" [1863]: Quart. Journ. Geol. Soc., 1864, vol. xx, pp. 103–111; Phil. Mag., 1864, vol. xxvii, p. 562.

"On the Correlation of the Cretaceous Formations of the North-East of Ireland" [1864]: Quart. Journ. Geol. Soc., 1865, vol. xxi, pp. 15–44; Phil. Mag., 1864, vol. xxviii, p. 562.

"A Descriptive Catalogue of the *Pteroceræ* of the Cretaceous Rocks": Geol. & Nat. Hist. Rep., 1865, pp. 91–93.

"On the so-called *Rostellariæ* of the Cretaceous Rocks, etc.": Geol. & Nat. Hist. Rep., 1865, pp. 93–102.
"Floral Immigration at Mitcham, Surrey": Intellectual Observer, 1866, vol. ix, pp. 284–288.
"A plain and easy Account of the Land and Fresh-water Molluscs of Great Britain," 8vo, London, 1866.
"Upon the Flora of the Shetland Isles": Journ. Bot., 1866, vol. iv, pp. 2–15.
"A New Variety of *Andromeda polifolia* (*A. curta*)": Journ. Bot., 1866, vol. iv, pp. 377–378.
"On the Occurrence of the Genus *Crassatella* in the Oolitic Rocks, with a Description of a New Species": Geol. & Nat. Hist. Rep., 1867, pp. 396–397.
"On the Liassic Species of D'Orbigny in his 'Prodrome de Paléontologie'": Geol. & Nat. Hist. Rep., 1867, pp. 394–396.
"On the oldest known Species of *Exogyra*, with a Description of the Species": Geol. & Nat. Hist. Rep., 1867, pp. 378–380.
"On the Liassic Affinities of the *Avicula contorta* Series": Geol. & Nat. Hist. Rep., 1867, pp. 364–369.
"On some Secondary Fossils from South Africa": Quart. Journ. Geol. Soc., 1867, vol. xxiii, pp. 139–175; Phil. Mag., 1867, vol. xxxiii, p. 396.
"On the Lower Lias of the North-East of Ireland": Quart. Journ. Geol. Soc., 1867, vol. xxiii, pp. 297–305; Phil. Mag., 1867, vol. xxxiv, p. 321.
"On the Fossiliferous Development of the Zone of *Ammonites angulatus*, Schloth., in Great Britain": Quart. Journ. Geol. Soc., 1867, vol. xxiii, pp. 305–315; Phil. Mag., 1867, vol. xxxiv, p. 321.
"Note on *Axinopsis*, gen. nov., *Schizodus*, et *Axinus*": Geol. Mag., 1868, Dec. I, Vol. V, p. 412.
"Species of Terrestrial Mollusca collected on the Island of San Lucia": Ann. Mag. Nat. Hist., 1869, vol. iv, p. 356.
"Contributions to Jurassic Palæontology: (1) *Cryptaulax*, a new genus of Cerithiadæ": Ann. Mag. Nat. Hist., 1869, vol. iv, pp. 417–419.
"On the Land and Fresh-water Mollusca of Nicaragua": Rep. Brit. Assoc., 1869, vol. xxxix, pp. 117–118; Amer. Journ. Conch., 1870, vol. v, pp. 151–162.
"On the Oldest British Belemnite—*B. præmaturus*": Geol. Mag., 1869, Dec. I, Vol. VI, pp. 166–167.
"Additions to the List of Brachiopoda of the British Secondary Rocks": Geol. Mag., 1869, Dec. I, Vol. VI, pp. 550–556.
"Notes on the Geology of Guyana in Venezuela": Quart. Journ. Geol. Soc., 1869, vol. xxv, pp. 343–350; Phil. Mag., 1870, vol. xxxix, pp. 386–387.
"A List of Irish Liassic Fossils, with Notes on the new and critical species": Proc. Belfast Nat. Field Club, 1870.
"Rudimentary Treatise on Geology," 1871. Pt. i: Physical Geology; 3rd ed., 8vo, London, 1879. Pt ii: Historical Geology; 2nd ed., 8vo, London, 1875.
"Note on the Middle Lias in the North-East of Ireland": Quart. Journ. Geol. Soc., 1870, vol. xxvi, pp. 324–325; Phil. Mag., 1870, vol. xl, p. 140.
"On the Palæontology of the Junction Beds of the Lower and Middle Lias in Gloucestershire": Quart. Journ. Geol. Soc., 1870, vol. xxvi, pp. 394–408.
"Addenda to the *Cybele Hibernica*": Journ. Bot., 1870, vol. viii, pp. 80–82.
"The Fuller's Earth in the South-West of England": Quart. Journ. Sci., 1870, vol. vii, pp. 68–71.
"On the Mandibles of Land and Fresh-water Gasteropoda": Student, 1870, vol. iv, pp. 401–411.
"A Census of the Marine Invertebrate Fauna of the Lias": Geol. Mag., 1871, Dec. I, Vol. VIII, pp. 4–11.
"On the Age of the Nubian Sandstone": Quart. Journ. Geol. Soc., 1871, vol. xxvii, pp. 404–406; Phil. Mag., 1871, vol. xlii, p. 388.
"Note on the Discovery of the Oldest Known *Trigonia* (*T. lingonensis*, Dumortier) in Britain": Geol. Mag., 1872, Dec. I, Vol. IX, p. 306.
"On the Palæontology of Skye and Raasay": Quart. Journ. Geol. Soc., 1873, vol xxix, pp. 339–351.
"On the Lias about Radstock [Somersetshire]": Quart. Journ. Geol. Soc., 1875, vol. xxxi, pp. 493–509.
"Rhætic and Liassic [Strata of the Bristol District] in Bristol and its Environs" (Rep. Brit. Assoc.), 8vo, Bristol, 1875.

"Appendix of Recent and Fossil Conchological Discoveries": see Woodward, S. P., "A Manual of the Mollusca," 3rd ed.; 12mo, London, 1875.
"On some New Liassic Fossils": Geol. Mag., 1875, Dec. II, Vol. II, pp. 203–6.
"On New Species of *Belemnites* and *Salenia* [*B. senescens*, Tate; *S. tertiaria*, Tate] from the Middle Tertiaries of South Australia": Quart. Journ. Geol. Soc., 1877, vol. xxxiii, pp. 256–258; Ann. Mag. Nat. Hist., 1877, vol. xix, p. 268.
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JAMES SHIPMAN, F.G.S.

BORN APRIL 30, 1848. DIED NOVEMBER 21, 1901.

AN energetic worker on geology has been lost to science in the death of Mr. James Shipman. In early life he was apprenticed to the printing trade; he subsequently entered the employment of the late Mr. Edmund Renals, then proprietor of the *Nottingham Daily Express*, and at the time of his death Mr. Shipman occupied a post on the sub-editorial staff. About the year 1868 he attended the science classes held by the late Edward Wilson, and in 1870 he won the bronze medal of the Science and Art Department for geology. Later on Mr. Shipman became a teacher in the science. He devoted himself with remarkable enthusiasm to the study of all the open geological sections in and around Nottingham, and furnished important aid to Mr. W. T. Aveline when he was revising the geological survey map of the district. He became an active member of the Nottingham Naturalists Society, contributing to its Transactions papers on the geology of various parts of Nottinghamshire and Derbyshire. The Drift deposits, the New Red Rocks, and the Coal-measures naturally attracted his chief attention, and so thoroughly sound was his knowledge that his advice was sought in various inquiries of economic importance. As a journalist his time was greatly occupied, and especially at night, so that it was only in leisure hours, often taken from those which should have been devoted to sleep, that he was enabled to give so much time to his favourite subject. In 1887 he published "Holiday Notes of a Geologist," a work which contained many interesting reminiscences. There can, however, be little doubt that by utilizing what he termed his 'free' days so fully, while labouring also at night, he too severely taxed his strength. He died suddenly at the age of 53.[1]

[1] We are indebted for most of the above particulars to an article by Mr. A. Stapleton in the *Nottingham Daily Express*.